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PALYNOLOGY OF THE LOWER CARBONIFEROUS WINDSOR GROUP AND WINDSOR-CANSO BOUNDARY BEDS OF NOVA SCOTIA, AND THEIR EQUIVALENTS IN QUEBEC, NEW BRUNSWICK AND NEWFOUNDLAND

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PREFACE

Lower Carboniferous rocks of eastern Quebec, New Brunswick, southwestern Newfoundland, and Nova Scotia, have attracted economic interest for many years as a possible source of mineral and petroleum deposits. Exploration throughout the area has been hindered by insufficient biostratigraphic information for precise age determination and correlation of the succession, both at the surface and in the subsurface. Palynology is especially valuable for resolving such problems in this area.

This detailed study of the spores and acritarchs from numerous sections, with the taxonomic description of fourteen new species, has resulted in the establishment of a biostratigraphic zonation for the Viséan rocks in the area, and correlation with the contemporaneous spore zonation of Western Europe. Studies of this nature are essential for the calibration of a regional geological time scale, which is necessary for precise dating and correlation. In addition, the study provides information concerning Early Carboniferous paleoenvironments and the paleoclimate of Atlantic Canada.

Also presented are thermal maturity data for selected sections in Atlantic Canada. The Thermal Alteration Indices were established from spore colouration and, when used in association with geochemical data, may indicate the liquid hydrocarbon potential of these strata.

R.A. Price
Director General
Geological Survey of Canada

PRÉFACE

Durant plusieurs années, les roches du Carbonifère inférieur de l'est du Québec, du Nouveau-Brunswick, du sud-ouest de Terre-Neuve et de la Nouvelle-Écosse ont attiré l'attention du point de vue de leur intérêt économique comme ressources potentielles minérales et pétrolifères. Les explorations à l'étendue de la région ont été effectuées sans une connaissance suffisante de la biostratigraphie dans la détermination précise de l'âge et de la corrélation de la succession en surface et en subsurface. La palynologie est expressément précieuse pour la solution de ces problèmes dans cette région.

Les études détaillées des spores et des acritarches provenant de nombreuses sections stratigraphiques, accompagnées des descriptions taxonomiques des quatorze nouvelles espèces, ont permis d'établir une zonation biostratigraphique pour les roches du Viséan de cette région, et de la corrélation avec une zonation de spores contemporaine de l'Europe occidentale. Les études de cette nature sont essentielles pour la calibration de l'échelle des temps géologiques régionaux nécessaires pour la précision de la datation et des corrélations. En plus, ces études apportent des renseignements concernant les paléoenvironnements et le paléoclimat au cours du Carbonifère inférieur de l'Atlantique canadien.

Aussi on présente les données sur la maturité thermique de quelques des sections de l'Atlantique canadien choisies. Les indices d'altération thermique sont établis à partir de la coloration de spores, et quant utiliser en association avec des données géochimiques, peuvent indiquer le potentiel d'hydrocarbures liquides dans ces strates.

Le directeur général de la
Commission géologique du Canada
R.A. Price

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PALYNOLOGY OF THE LOWER CARBONIFEROUS WINDSOR GROUP AND WINDSOR-CANSO BOUNDARY BEDS OF NOVA SCOTIA, AND THEIR EQUIVALENTS IN QUEBEC, NEW BRUNSWICK AND NEWFOUNDLAND

Abstract

Three miospore concurrent range zones are recognized in samples from the Windsor Group, and Windsor-Canso Group boundary beds of Nova Scotia, and from lithostratigraphic and biostratigraphic equivalents in Quebec, New Brunswick, and Newfoundland. The zones are: *Lycospora noctuina* var. *noctuina* - *Knoxisporites stephanephorus* (NS) Zone; *Schopfipollenites acadiensis* - *Knoxisporites triradiatus* (AT) Zone; and *Grandispora spinosa* - *Ibrahimispores magnificus* (SM) Zone. The NS Zone is coeval with macrofaunal Subzones A and B; the AT Zone with macrofaunal Subzones C, D and E; and the SM Zone with beds younger than Subzone E.

Fourteen new miospore species and three new varieties are described: *Anapiculatisporites fundiensis*, *Convolutispora labyrinthea*, *Densosporites columbaris*, *Dictyotriletes odontolophos*, *Discernisporites barssii*, *Discernisporites diaphanes*, *Knoxisporites probolos*, *Microreticulatisporites hacquebardii*, *Neoraistrickia versiforma*, *Raistrickia magdalena*, *Schopfipollenites acadiensis*, *Schulzospora bilunata*, *Scutulum trisupplementum*, *Spelaeotriletes pretiosus* var. *pretiosus*, *Spelaeotriletes pretiosus* var. *bellii*, *Spelaeotriletes pretiosus* var. *windsorensis*, and *Spelaeotriletes tuberosus*. Two new acritarch species, *Leiospheridia*? *scotia* and *Eisenackidium playfordii*, are described. Two new miospore species (*Granulatisporites* sp. cf. *G. tuberculatus* and *Knoxisporites* sp. A), and three acritarch species (*Actinotodissus* sp. A, *Elektoriskos* sp. A, and *Leiosphaeridia*? sp. A) are described, but not named because of insufficient material. Three new combinations are formally proposed: *Cristatisporites submarginatus* (Playford), *Discernisporites macromanifestus* (Hacquebard) and *Spelaeotriletes echinatus* (Hacquebard). Two species are emended: *Spelaeotriletes pretiosus* (Playford) Neves and Belt emend., and *Spelaeotriletes echinatus* (Hacquebard) emend.

Palynostratigraphic correlation with Western Europe suggests a Viséan V_2 to V_3 age for the Lower Windsor Group, and a Viséan V_3 age for the Upper Windsor and Windsor-Canso Group boundary beds.

Assemblages are not diverse and probably represent a vegetation restricted by a hot, arid climate. Shoreline swamp vegetation may also have been limited, due to high salinity; this could explain the scarcity of *Densosporites*.

The Thermal Alteration Index varies throughout the area from 2- to 4.

Résumé

Trois zones de cooccurrence de miospores sont identifiées dans des échantillons provenant du Groupe de Windsor, des couches-limites du Groupe de Windsor-Canso de la Nouvelle-Écosse, et des équivalents lithostratigraphiques et biostratigraphiques du Québec, du Nouveau-Brunswick et de Terre-Neuve. Les zones sont les suivantes: *Lycospora noctuina* var. *noctuina* - *Knoxisporites stephanephorus* (NS); *Schopfipollenites acadiensis* - *Knoxisporites triradiatus* (AT); et *Grandispora spinosa* - *Ibrahimispores magnificus* (SM). La zone NS est du même âge que les sous-zones des macrofaunes A et B; la zone AT est du même âge que les sous-zones des macrofaunes C, D, et E; et la zone SM est contemporaine aux couches plus jeunes que celles de la sous-zone E.

Dans la présente étude, quatorze nouvelles espèces de miospores et trois nouvelles variétés sont décrites: *Anapiculatisporites fundiensis*, *Convolutispora labyrinthea*, *Densosporites columbaris*, *Dictyotriletes odontolophos*, *Discernisporites barssii*, *Discernisporites diaphanes*, *Knoxisporites probolos*, *Microreticulatisporites hacquebardii*, *Neoraistrickia versiforma*, *Raistrickia magdalena*, *Schopfipollenites acadiensis*, *Schulzospora bilunata*, *Scutulum trisupplementum*, *Spelaeotriletes pretiosus* var. *pretiosus*, *Spelaeotriletes pretiosus* var. *bellii*, *Spelaeotriletes pretiosus* var. *windsorensis*, et *Spelaeotriletes tuberosus*. Deux nouvelles espèces d'acritarches, *Leiospheridia*? *scotia* et *Eisenackidium playfordii*, sont décrites. Deux espèces de miospores (*Granulatisporites* sp. cf. *G. tuberculatus* et *Knoxisporites* sp. A), et trois espèces d'acritarches (*Actinotodissus* sp. A, *Elektoriskos* sp. A and *Leiosphaeridia*? sp. A), sont également discutées, sans être dénommées, puisque l'on ne dispose pas des échantillons requis. On propose formellement trois nouvelles combinaisons comme suit: *Cristatisporites submarginatus* (Playford), *Discernisporites macromanifestus* (Hacquebard) et *Spelaeotriletes echinatus* (Hacquebard). On a émendé deux espèces, *Spelaeotriletes pretiosus* (Playford) Neves and Belt emend. et *Spelaeotriletes echinatus* (Hacquebard) emend.

La corrélation palynostratigraphique avec l'Europe occidentale suggère un âge viséan de V_2 à V_3 pour le Groupe de Windsor inférieur et un âge viséan de V_3 pour le Groupe de Windsor supérieur et les couches-limites du Groupe de Windsor-Canso.

Les assemblages ne sont pas variés et représentent fort probablement une végétation limitée par un climat chaud et aride. La végétation littorale de marais, possiblement très limitée à cause d'une salinité élevée, pourrait expliquer la rareté de *Densosporites*.

La variation régionale de l'index d'altération thermique se situe entre 2- et 4.

Summary

1. The Windsor Group of Nova Scotia is underlain by the Horton Group and overlain by the Canso Group. In most localities, the lower contact is an angular unconformity or disconformity, and the upper contact is either an angular unconformity or disconformity, or it is conformable (Windsor-Canso Group boundary beds). The Lower Windsor Group consists of thin, basal marine carbonates overlain by generally massive evaporites, which in turn grade upsection into interbedded evaporites and thin, highly fossiliferous carbonates. The Upper Windsor Group is a thick succession of mostly fine grained, red siliciclastics, which are sporadically intercalated with evaporites and thin, fossiliferous carbonates. The Windsor-Canso Group boundary reflects a change from marine to essentially lacustrine conditions, but salinity did remain high and the climate arid, as witnessed by the anhydrite intercalations in these essentially argillaceous, and fine grained, arenaceous beds.

2. Palynological studies were completed on 139 surface and 143 subsurface samples from the Windsor and lowermost Canso groups of Nova Scotia, and their lithostratigraphic and biostratigraphic equivalents in Quebec (Magdalen Islands), New Brunswick, and Newfoundland. Miospores occur in grey shale, siltstone, and argillaceous carbonate, salt and anhydrite; they are absent in the red siliciclastics and are rare or absent in the nonargillaceous carbonates. Fourteen new miospore species and three varieties are described. They are: *Anapiculatisporites fundiensis*, *Convolutispora labyrinthea*, *Densosporites columbaris*, *Dictyotriletes odontolophos*, *Discernisporites barssii*, *Discernisporites diaphanes*, *Knoxisporites probolos*, *Microreticulatisporites hacquebardii*, *Neoraistrickia versiforma*, *Raistrickia magdalena*, *Schopfipollenites acadiensis*, *Schulzospora bilunata*, *Scutulum trisupplementum*, *Spelaeotriletes pretiosus* var. *pretiosus*, *Spelaeotriletes pretiosus* var. *bellii*, *Spelaeotriletes pretiosus* var. *windsorensis*, and *Spelaeotriletes tuberosus*. Two new acritarch species, *Leiospheridia*? *scotia* and *Eisenackidium playfordii*, are also described. Two new miospore species, *Granulatisporites* sp. cf. *G. tuberculatus* and *Knoxisporites* sp. A, and three acritarch species, *Actinotodissus* sp. A, *Elektoriskos* sp. A, and *Leiosphaeridia*? sp. A are described, but not named because of insufficient material. Three new combinations are formally proposed: *Cristatisporites submarginatus* (Playford), *Discernisporites macromanifestus* (Hacquebard) and *Spelaeotriletes echinatus* (Hacquebard). Two species are emended: *Spelaeotriletes pretiosus* (Playford) Neves and Belt emend., and *Spelaeotriletes echinatus* (Hacquebard) emend.

3. Three miospore concurrent range zones are established here: *Lycospora noctuina* var. *noctuina* -*Knoxisporites stephanephorus* (NS) Zone; *Schopfipollenites acadiensis* - *Knoxisporites triradiatus* (AT) Zone; and *Grandispora spinosa* - *Ibrahimispores magnificus* (SM) Zone. The NS Zone is coeval with Lower Windsor macrofaunal Subzones A and B; the AT Zone with Upper Windsor macrofaunal Subzones C, D and E; and the SM Zone with beds younger than Subzone E at the Windsor-Canso Group boundary. The macrofaunal zones are based on brachiopods, corals, molluscs, and trilobites (Bell, 1929).

4. Palynostratigraphic studies of Western European and British spore zones and stages suggest a correlation of the NS Zone with the upper part of the *Lycospora pusilla* Zone of Viséan V_2 to V_3, or Arundian (?) to Holkerian age; the AT Zone correlates with the *Perotrilites tessellatus* - *Schulzospora campyloptera* (TC) Zone and the *Raistrickia nigra* - *Triquitrites marginatus* (NM) Zone of Viséan V_3, or Asbian age; and the SM Zone correlates with the *Tripartites vetustus* - *Rotaspora fracta* Zone of Viséan V_3, or Brigantian age. The Viséan ages indicated by the palynological data compare well with those proposed by Bell (1929) based on the macrofauna. Similarly, a Holkerian age for at least the upper part of the Lower Windsor Group is supported by conodont data (von Bitter and Austin, 1984). Nevertheless, the ages suggested here are generally slightly older than those proposed by Mamet (1970) from data on foraminifers and algal microflora.

5. The spore assemblages are not diverse; almost all Windsor samples containing palynomorphs are dominated by *Crassispora trychera* and *Rugospora minuta*, and those from the Windsor-Canso Group boundary by *Crassispora trychera*. This probably reflects the lack of vegetational variety caused by a hot arid climate. In addition, the salinity of the Windsor sea was mostly very high, with only occasional influxes of less saline water, reflected by the presence of carbonates containing a rich macrofauna. It is probable that a shallow marine, hypersaline facies persisted while the Windsor Group was being deposited, even when conditions of normal to slightly supersaturated salinity occurred farther out to sea (Mamet, 1970). This unusal variation in environments may have developed in a marine, landlocked, trough-like embayment. Shoreline swamp vegetation would have been limited by the high salinity and this, along with an arid climate, could explain the scarcity of *Densosporites*, which is common elsewhere in Viséan marine shoreline sediments deposited in a humid climate. Spore transportation was probably mainly by wind, which may account for the consistent quantitative proportions of species found between samples vertically and laterally. Acritarchs are rare in Windsor Group samples; this could well be related to the high salinity of the sea at that time.

6. Lower Carboniferous microfloras of Atlantic Canada may be assigned to the *Vallatisporites* Region of Van der Zwan (1981), which included the subtropical dry belt of south Euramerica, extending from eastern Canada through Ireland, Great Britain, and Denmark.

7. The Thermal Alteration Index (T.A.I.) varies from 2- to 3 for most samples throughout the study areas, suggesting that conditions in many localities may have been suitable for the generation of oil. However, in some localities the T.A.I. is higher. For example, in strata equivalent to the Lower Windsor in the southern part of the Magdalen Islands (near Havre-aux-Maisons, Havre-aux-Maisons Island), the T.A.I. is 3+; for equivalents of the Windsor Group and Windsor-Canso Group boundary beds of southwestern Newfoundland, the T.A.I. is 3 to 3+. The highest values (T.A.I. 4- to 4), at a maturation beyond the zone for oil generation, were found in Windsor deposits offshore of northern Cape Breton in the Petro-Canada et al., St. Paul P-91 well.

Sommaire

1. Le Groupe de Windsor de la Nouvelle-Écosse succède du Groupe de Horton et est surmonté par le Groupe de Canso. Dans la majorité des localités, le contact inférieur est une discordance angulaire ou une discordance plate, et le contact supérieur est soit une discordance angulaire, une discordance plate, ou concordant (à titre d'exemple, les couches-limites du groupe de Windsor-Canso). Le Groupe de Windsor inférieur se compose à la base de carbonates minces et marins qui sont recouverts d'évaporites généralement massives; celles-ci, en montant dans la séquence stratigraphique, passent à des évaporites interstratifiées avec de minces carbonates très fossilifères. Le Groupe de Windsor supérieur comprend une succession épaisse composée principalement de siliciclastiques rouges à grains fins intercalées sporadiquement d'évaporites, et de carbonates minces et fossilifères. La limite entre les groupes de Windsor et Canso signale la transition des conditions marines à des conditions principalement lacustres. Cependant, la salinité demeurait élevée sous un climat aride, tel que témoigné par des intercalations d'anhydrites dans ces couches, pour la plupart argileuses, arénacées, et à grains fins.

2. Des études palynologiques ont été achevées sur quelques 139 échantillons de surface et quelques 143 échantillons de subsurface provenant du Groupe de Windsor, de l'extrême base du Groupe de Canso inférieur de la Nouvelle-Écosse, et de leurs équivalents lithostratigraphiques et biostratigraphiques du Québec (les Îles-de-la-Madeleine), du Nouveau-Brunswick, et de Terre-Neuve. Des miospores sont présentes dans le schiste argileux gris, le grès très fin, le carbonate argileux, le sel, et l'anhydrite; elles ne sont pas présentes dans les siliciclastiques rouges, et sont clairsemées ou absentes dans les carbonates non-argileux. Quatorze nouvelles espèces de miospores et trois variétés sont décrites dans la présente étude: *Anapiculatisporites fundiensis*, *Convolutispora labyrinthea*, *Densosporites columbaris*, *Dictyotriletes odontolophos*, *Discernisporites barssii*, *Discernisporites diaphanes*, *Knoxisporites probolos*, *Microreticulatisporites hacquebardii*, *Neoraistrickia versiforma*, *Raistrickia magdalena*, *Schopfipollenites acadiensis*, *Schulzospora bilunata*, *Scutulum trisupplementum*, *Spelaeotriletes pretiosus* var. *pretiosus*, *Spelaeotriletes pretiosus* var. *bellii*, *Spelaeotriletes pretiosus* var. *windsorensis*, et *Spelaeotriletes tuberosus*. Deux nouvelles espèces d'acritarches, *Leiospheridia*? *scotia* et *Eisenackidium playfordii*, sont également décrites. Deux nouvelles espèces de miospores, *Granulatisporites* sp. cf. *G. tuberculatus* et *Knoxisporites* sp. A, et trois espèces d'acritarches, *Actinotodissus* sp. A, *Elektoriskos* sp. A, et *Leiosphaeridia*? sp. A, sont décrites mais non formellement nommées puisque l'on ne disposait pas d'un nombre suffisant de spécimens. Trois combinaisons nouvelles sont proposées formellement: *Cristatisporites submarginatus* (Playford), *Discernisporites macromanifestus* (Hacquebard) et *Spelaeotriletes echinatus* (Hacquebard). On a émendé deux espèces comme suit: *Spelaeotriletes pretiosus* (Playford) Neves and Belt emend., et *Spelaeotriletes echinatus* (Hacquebard) emend.

3. Trois zones de cooccurrence de miospores sont établies tels que *Lycospora noctuina* var. *noctuina* -*Knoxisporites stephanephorus* (NS); *Schopfipollenites acadiensis* - *Knoxisporites triradiatus* (AT); et *Grandispora spinosa* -*Ibrahimispores magnificus* (SM). La zone NS est du même âge que les sous-zones des macrofaunes A et B du Groupe de Windsor inférieur; la zone AT est du même âge que les sous-zones C, D, et E du Groupe de Windsor supérieur; et la zone SM est du même âge que les couches plus jeunes que celles de la sous-zone E à la limite Windsor-Canso. Les zones de macrofaunes sont classées selon leur contenu de brachiopodes, de coraux, de mollusques et de trilobites (Bell, 1929).

4. L'étude palynostratigraphique des zones de spores de l'Europe occidentale et de la Grande-Bretagne suggère une corrélation entre la zone NS et la partie supérieure de la zone de *Lycospora pusilla* d'âge viséan V_2 à V_3, et d'âge arundien(?) à holkérien. La zone AT correspond à la zone *Perotrilites tessellatus* - *Schulzospora campyloptera* (TC) et la zone *Raistrickia nigra* - *Triquitrites marginatus* (NM) d'âge viséan V_3 ou asbien, et la zone SM correspond à la zone d'âge viséan V_3 ou brigantien. L'étude palynologique a confirmé les âges viséans obtenu par Bell (1929) basés sur la macrofaune. D'une manière semblable, un âge holkérien pour au moins la partie supérieure du Groupe de Windsor inférieur est proposé et confirmé par les données prélevées de conodontes (von Bitter and Austin, 1984). Cependant, les âges proposés dans la présente étude sont légèrement plus vieux que ceux proposés par Mamet (1970), basées sur les foraminifères et les microflores algaires.

5. Les assemblages de spores ne sont pas variés; presque tous les échantillons qui contiennent des palynomorphes sont dominés par *Crassispora trychera* et *Rugospora minuta*, et ceux provenant de la limite Windsor-Canso sont dominés par *Crassispora trychera*. Ce fait indique probablement une manque de variété dans la végétation, causé par un climat chaud et aride. En plus, la salinité de la mer de Windsor était pour la plupart très élevée, à l'exception des périodes de pénétration intermittente des eaux moins salines, ce qui est évident dans les carbonates riches en macrofaunes. On considère qu'un faciès hypersalin dans une mer peu profonde persistait au cours de la déposition du Groupe de Windsor, ce qui comprend les périodes où les conditions de salinité normale à légèrement sursaturée existaient dans la mer plus profonde (Mamet, 1970). Cette variation peu commune de l'environnement aurait pu survenir dans une baie marine formant une dépression allongée, entourée de terres. Le genre *Densosporites* est normalement associé aux sédiments littoraux marins viséans, habituellement accumulés sous des conditions climatiques humides. La rareté de *Densosporites* observée dans le Groupe de Windsor peut s'expliquer par une faible diversité de la végétation des marais littoraux, suite à une salinité élevée et un climat aride. Les spores étaient emportées probablement en grande proportion par le vent, ce qui pourrait expliquer les constances des proportions quantitatives des espèces qui sont évidentes verticalement ainsi que horizontalement à travers le bassin. Les acritarches sont rarement présentes, ce qui était possiblement dû à la salinité de la mer à cette époque-là.

6. Les microflores d'âge carbonifère inférieur de l'Atlantique canadien peuvent être attribuées à la région de *Vallatisporites* de Van der Zwan (1981), une ceinture qui comprenait la région sèche subtropicale de l'Euramérique méridionale (Canada oriental, Irelande, Grande-Bretagne, et Danemark).

7. L'index d'altération thermique (I.A.T.) varie de 2- à 3 pour la plupart des échantillons provenant des régions étudiées, ce qui suggère que plusieurs localités offraient des conditions possiblement favorables pour la génération d'hydrocarbures. Cependant, dans quelques localités, l'I.A.T. est plus élevé. On remarque, par exemple, que dans les strates équivalentes du Groupe de Windsor inférieur de la partie méridionale des Îles-de-la-Madeleine (près de Havre-aux-Maisons, à l'Île de Havre-aux-Maisons), l'I.T.A. est de 3+; pour des équivalents du Groupe de Windsor et les couches-limites du Groupe de Windsor-Canso de Terre-Neuve sud-ouest, l'I.T.A. varie de 3 à 3+. Les valeurs les plus élevées de l'I.T.A. (entre 4- à 4), correspondant à un niveau de maturation hors de la zone de génération des hydrocarbures, se trouvaient dans les sédiments du Groupe de Windsor au large des côtes du Cap-Breton dans le puits de forage Petro-Canada et al., St. Paul P-91.

PALYNOLOGY OF THE LOWER CARBONIFEROUS WINDSOR GROUP AND WINDSOR-CANSO BOUNDARY BEDS OF NOVA SCOTIA, AND THEIR EQUIVALENTS IN QUEBEC, NEW BRUNSWICK AND NEWFOUNDLAND

INTRODUCTION

Bell (1929, p. 45) introduced the term Windsor Series in Nova Scotia for a group of soft, mostly restricted marine sediments that underlie the lowlands near the Avon River and its tributaries. The rock types of the group vary considerably. Geldsetzer (1978) described the Lower Windsor Group as consisting of "thin basal carbonates overlain by generally massive evaporites, which in turn grade upsection into interbedded evaporites and thin, highly fossiliferous carbonates". The Upper Windsor Group "is a thick succession of mostly fine grained, red clastics which are periodically interrupted by evaporites and thin fossiliferous carbonates".

Underlying the Windsor Group is the Horton Group. In most localities, it is not very difficult to recognize the contact between the two groups, as an unconformity or disconformity is commonly present. Where there is no obvious unconformity, the contact may be more difficult to locate precisely, especially in subsurface sections. The Windsor Group is overlain by the Canso Group, and the contact between these two groups at certain localities is a source of disagreement. For example, some workers consider the top of the uppermost marine carbonate to represent the top of the Windsor Group, whereas others use the top of the uppermost thick gypsum and (or) anhydrite bed. This problem was discussed by Utting (1980, p. 1032). In other localities, rocks like those of the Canso Group may rest locally on the basal limestone of the Windsor Group. This occurs, for example, south of the Canso Strait, in southern Cape Breton Island, and east of Antigonish along the coast (Geldsetzer, pers. comm., 1984). Bell (1929) recognized two zones: a Lower Windsor *Composita dawsoni* Zone, an Upper Windsor *Martinia galatea* Zone and five macrofaunal subzones (A, B, C, D, and E). Macrofaunal Subzones A and B occur in the Lower Windsor, and C, D, and E in the Upper Windsor (see Table 1). All of these subzones contain distinctive faunas, with the exception of Subzone A, which contains only species of the lamellibranch *Schizodus*. It is, however, characterized by the distinctive lithotypes of banded brecciated limestone, thin conglomerate and basal sandstone. Thus, Subzone A is not a true paleontological zone but rather a distinctive lithostratigraphic unit. In 1958, Bell used the term Windsor Group instead of 'series' and suggested that a further subzone, F, was present in the youngest Windsor beds. Subsequent investigators (e.g., Mamet, 1970), found Subzone F to be time equivalent to Subzone E. Thus, the current usage of the formal subdivisions of the Windsor Group (i.e., Lower and Upper) is not very different from Bell's original classification in 1929. In this paper they are also used formally, with initial capital letters.

TABLE 1

Summary of Lower Carboniferous stratigraphic divisions in Nova Scotia

SYSTEM	STAGE	GROUP	FORMATION OR ROCK UNIT	MACROFAUNAL SUBZONE
SILESIAN	NAMURIAN A	CANSO	POMQUET	
		?—?	Boundary beds[1]	
DINANTIAN	VISÉAN	WINDSOR	UPPER WINDSOR	E D C
			LOWER WINDSOR	B A
			unconformity or disconformity	
	TOURNAISIAN	HORTON	CHEVERIE	
			disconformity ?	
			HORTON BLUFF	

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[1] e.g. Hastings Formation and "Watering Brook Formation"

The present paper is a compilation of palynological data obtained from various outcrops of, and boreholes through, the Windsor Group and the lowermost part of the Canso Group in Nova Scotia, and beds which are lateral equivalents in New Brunswick, Newfoundland and Quebec (see Figure 1). Formal names have been proposed for three miospore zones and it is believed that these zones are valid throughout the study area. Taxonomic descriptions have been given for new species and varieties; emended descriptions of species and new combinations are listed; and species are described only if there are any significant differences from the original description.

Previous work

The history of paleontological research concerning the Windsor Group of Nova Scotia and its lateral equivalents in other parts of Atlantic Canada dates back over 50 years. A variety of fossil groups is represented, many of which reflect the marine conditions that at times prevailed during deposition; it is, as far as is known, the only Carboniferous unit containing marine rocks in Atlantic Canada. The Horton and Canso groups are thought by most workers to be essentially nonmarine, although brackish water conditions may be represented by parts of the Canso Group (e.g., Copeland, 1957, p. 6). Compared to the Windsor Group fauna, the fauna of the Horton and Canso groups lacks variety.

A list of selected paleontological papers on the Lower Carboniferous rocks of Nova Scotia appears in Table 2. Publications listed are those that contain original information concerning the probable age of the fossils and also those that suggest biostratigraphic correlations with other areas; papers lacking such data are mentioned in the text.

Bell (1929) summarized the previous work concerning the Horton Bluff and Cheverie formations. An early Mississippian age (probably not later than Kinderhookian) was suggested for the Horton Bluff Formation, based on the identifications of plant, fish and ostracode remains. The Cheverie Formation, which contains plants, fish scales, and branchiopods, was not precisely dated. It was considered by Bell (1929) to lie unconformably on the Horton Bluff Formation and to be overlain unconformably by the Windsor Group of late Mississippian age. He suggested that the stratigraphic break between the Horton Bluff and Cheverie formations was possibly greater than that between the Cheverie Formation and the Windsor Group. The Windsor Group was zoned by Bell (1929) using brachiopods, corals, molluscs and trilobites. As mentioned in the introduction, Bell recognized five macrofaunal subzones: Subzones A and B in the Lower Windsor; and Subzones C, D, and E in the Upper Windsor. In terms of the European stages, he considered the Lower Windsor to be middle Viséan and noted the similarities with the *Seminula* Zone (S_2) of the Avonian sequence. The

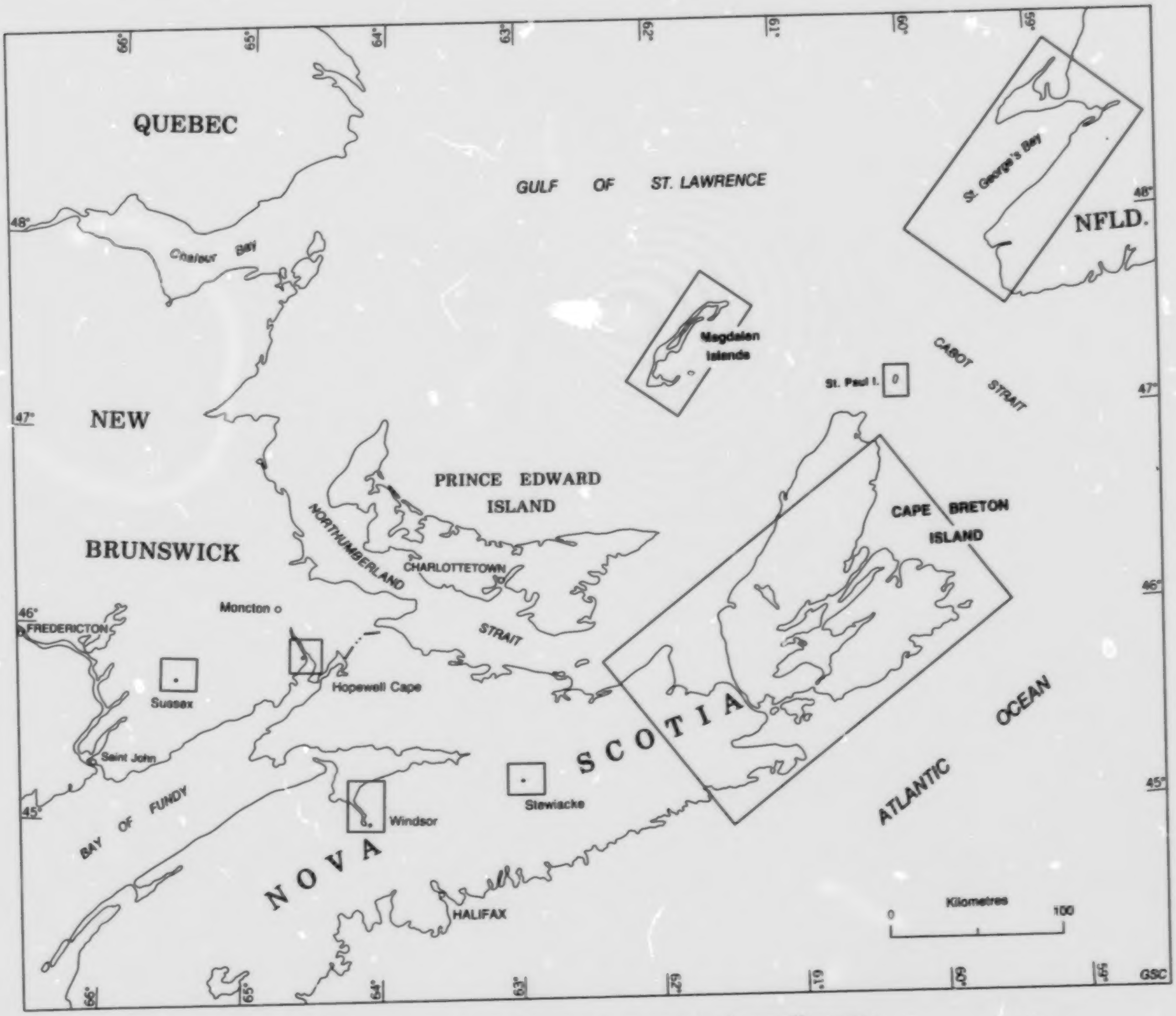

66°
65°
64°
63°
62°
61°
60°
59°
48°
47°
46°
45°
QUEBEC
GULF OF ST. LAWRENCE
St. George's Bay
NFLD.
Chaleur Bay
Magdalen Islands
St. Paul I.
CABOT STRAIT
NEW BRUNSWICK
PRINCE EDWARD ISLAND
NORTHUMBERLAND STRAIT
CHARLOTTETOWN
CAPE BRETON ISLAND
Moncton
FREDERICTON
Sussex
Hopewell Cape
Saint John
BAY OF FUNDY
Windsor
Stewiacke
NOVA SCOTIA
ATLANTIC OCEAN
HALIFAX
Kilometres
0
100
GSC

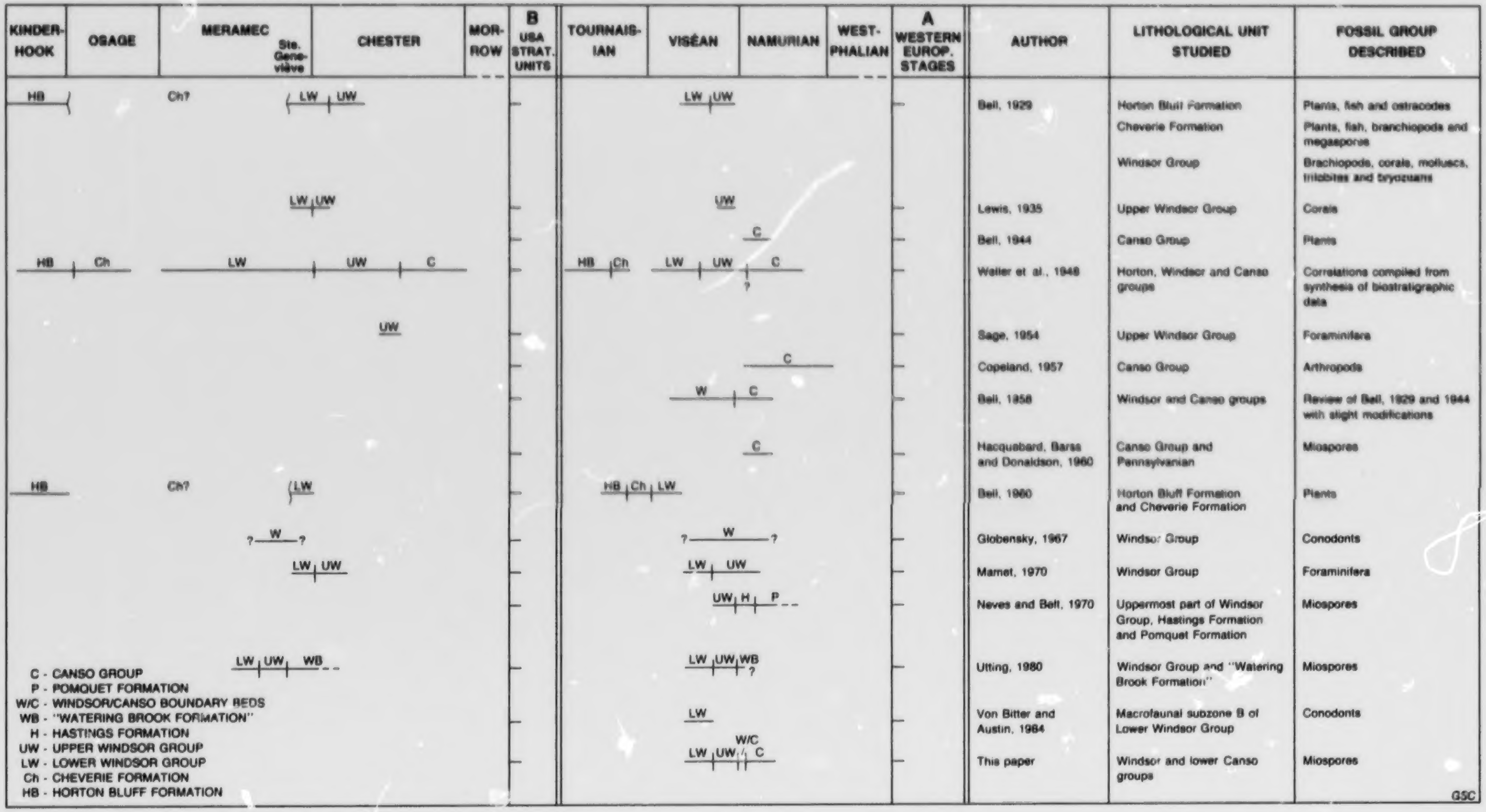
Figure 1. *Map of Atlantic Canada showing main sampling areas.*

Upper Windsor he assigned to the upper Viséan and proposed a correlation with the *Dibunophyllum* Zone of the Avonian. Problems concerning correlation with the Mississippi Valley of the United States were outlined by Bell (1929); they are largely the result of the faunal differences between the Windsor Group and rocks of a similar age in the Mississippi Valley. He considered the faunas from the Lower and Upper Windsor groups to have affinities with those of the Chesterian Series, although he thought the Lower Windsor might in part be equivalent to the Sainte Geneviève.

Lewis (1935) studied the corals from the Upper Windsor Group and considered them to be age equivalent to the Upper *Dibunophyllum* Subzones (D_{2-3}). He discussed the problems concerning the correlation of Windsor faunas with material from the United States, and concluded that until further evidence was available, the Lower Windsor was equivalent to the Sainte Geneviève, and the Upper Windsor was equivalent to the lowest Chester.

Bell (1944) published a paper on the floras from the Canso, Riversdale, Cumberland and Pictou groups. The Canso Group, which overlies the Windsor Group, contains fairly abundant lamellibranchs (*Anthracomya angulata* Dawson) and branchiopods, as well as plant fossils, which he considered indicated a Namurian A age.

Weller et al., (1948, chart no. 5), using the biostratigraphic data from Eastern Canada published by previous workers, proposed correlations with the North American stratigraphic divisions and with the European stages. They correlated the Horton Bluff with the upper part of the Kinderhookian Series and the lowermost part of the Osagean Series. Both units were considered to be of Tournaisian age. The Lower Windsor Group they correlated with the Meramecian Series, and the Upper Windsor Group with the lower Chesterian and uppermost part of the Meramecian. They suggested that most of the group was of Viséan age, although they placed the Viséan-Namurian boundary slightly



KINDERHOOK	OSAGE	MERAMEC Ste. Geneviève	CHESTER	MORROW	B USA STRAT. UNITS	TOURNAISIAN	VISÉAN	NAMURIAN	WESTPHALIAN	A WESTERN EUROP. STAGES	AUTHOR	LITHOLOGICAL UNIT STUDIED	FOSSIL GROUP DESCRIBED
HB		Ch? LW	UW				LW UW				Bell, 1929	Horton Bluff Formation	Plants, fish and ostracodes
												Cheverie Formation	Plants, fish, branchiopods and megaspores
												Windsor Group	Brachiopods, corals, molluscs, trilobites and bryozoans
		LW	UW				UW				Lewis, 1935	Upper Windsor Group	Corals
								C			Bell, 1944	Canso Group	Plants
HB	Ch	LW	UW C			HB Ch	LW UW	? C			Weller et al., 1948	Horton, Windsor and Canso groups	Correlations compiled from synthesis of biostratigraphic data
			UW								Sage, 1954	Upper Windsor Group	Foraminifera
								C			Copeland, 1957	Canso Group	Arthropods
							W	C			Bell, 1958	Windsor and Canso groups	Review of Bell, 1929 and 1944 with slight modifications
								C			Hacquebard, Barss and Donaldson, 1960	Canso Group and Pennsylvanian	Miospores
HB		Ch? LW				HB Ch	LW				Bell, 1960	Horton Bluff Formation and Cheverie Formation	Plants
		? W ?					? W ?				Globensky, 1967	Windsor Group	Conodonts
		LW	UW				LW UW				Mamet, 1970	Windsor Group	Foraminifera
							UW	H P - -			Neves and Bell, 1970	Uppermost part of Windsor Group, Hastings Formation and Pomquet Formation	Miospores
		LW UW	WB - -				LW UW	WB ?			Utting, 1980	Windsor Group and "Watering Brook Formation"	Miospores
							LW				Von Bitter and Austin, 1984	Macrofaunal subzone B of Lower Windsor Group	Conodonts
							LW UW	W/C C			This paper	Windsor and lower Canso groups	Miospores

C - CANSO GROUP
P - POMQUET FORMATION
W/C - WINDSOR/CANSO BOUNDARY BEDS
WB - "WATERING BROOK FORMATION"
H - HASTINGS FORMATION
UW - UPPER WINDSOR GROUP
LW - LOWER WINDSOR GROUP
Ch - CHEVERIE FORMATION
HB - HORTON BLUFF FORMATION

GSC

TABLE 2

Age determinations made from original paleontological data. Section A shows correlations with the European stages, and Section B shows correlations with stratigraphic units of the United States below the top of the Windsor Group. The Canso Group was correlated with the upper part of the Chesterian Series and was of early Namurian age (see Table 2).

Stacy (1953) traced the macrofaunal subzones of Bell (1929) to the Cape Breton area and found that Bell's subzones were applicable regionally. He did not attempt to correlate outside the study area, relying on the correlations proposed by Bell (1929) and Lewis (1935).

Sage (1954) examined some calcareous foraminifers from the uppermost part of the Upper Windsor and suggested that Subzone E may be correlated with the mid-Chester of the Mississippi Valley.

Copeland (1957) studied the Upper Carboniferous arthropods from the Maritime Provinces, but found difficulty correlating the rocks with strata outside the region. In general, the ostracodes, and a species of the mysidacean genus *Tealliocaris*, are similar to those known from the Lower Carboniferous of Scotland. In the upper Canso unit, conchostracans indicate an early Late Carboniferous age. Copeland (1957) suggested a Namurian age for the Canso Group largely on the basis of the flora described by Bell (1944), and on the fact that the Canso Group overlies the Windsor Group, from which Bell (1929) recorded a Viséan marine fauna.

The first published palynological work concerning the Mississippian of Atlantic Canada was by Hacquebard (1957). He studied material from the Horton Bluff Formation and beds that were considered to be lateral equivalents. In his view, the assemblages indicated a continuation of the Upper Devonian flora into the early part of the Early Carboniferous. No precise age determination was possible at that time because of the lack of palynological data for other localities that had good stratigraphic control from macrofossils.

Bell (1958) published a report concerning the possibility of finding liquid hydrocarbons in Nova Scotia. In that publication, the age of the Windsor Group was given as Viséan and that of the Canso Group as (?)late Viséan and early Namurian. It is presumed that a (?)late Viséan age was proposed, although it was not actually stated, because the Upper Windsor was dated as equivalent to the *Dibunophyllum* Zone of the Avonian succession (Bell, 1929) and the Canso Group was thought to rest conformably in some places on the Windsor Group (Bell, 1944). Thus, assuming that the age determination of the Upper Windsor is correct, it would be reasonable to conclude that rocks resting conformably on sediments correlated with the *Dibunophyllum* Zone would be equivalent either to the upper part of the same zone and/or to part of the overlying *Eumorphoceras* (E_1) Zone of early Namurian age.

Hacquebard, Barss and Donaldson (1960) gave a general review of the spores in the Upper Carboniferous of the Maritime Provinces. They assigned the Canso Group to Namurian A, but this age determination was based on the megafloral evidence provided by Bell (1944).

Bell (1960) published a memoir on the type section of the Horton Group in the Windsor-Horton district. He considered the plants in the Horton Bluff and Cheverie formations as indicative of an age approximately similar to the Pocono flora of the Appalachian area of the United States. The two most common and characteristic species that range through the group are *Aneimites acadica* Dawson and *Lepidodendropsis corrugata* (Dawson) Bell. The Cheverie Formation contains some species that are lacking in the Horton Bluff Formation, but because of the relatively small number of species identified in the group, Bell (1960) did not consider that there was sufficient evidence to state that there were two distinctive floras. He assigned the Horton Bluff and Cheverie formation flora to the Tournaisian, and considered the Cheverie to be no younger than late Tournaisian, because it was overlain by the Windsor Group, which contains marine fauna of early Viséan (late Meramecian) age. The early Viséan age quoted in that publication is not consistent with the middle Viséan age Bell proposed for the Lower Windsor Group in 1929, but no explanation for this change was given.

Playford (1964) studied the miospores of the Horton Bluff and Cheverie formations and recognized two assemblage zones, one from each formation.

Poole, Kelley and Neale (1964) questioned certain aspects of the general stratigraphic approach of Bell (1929, 1944, 1958, 1960). They maintained that although he recognized the transgressive nature of lithological units within individual Carboniferous groups, he did not recognize the transgressive and regressive relationships between one "group" and another. They suggested that "the contacts between most, if not all, of the 'groups' are conformable at some localities and disconformable or unconformable at others. The age of some conformable contacts probably varies from place to place". They gave a number of examples of how Bell's definition of various groups was time restricted, whereas according to them, the evidence indicated that certain parts of certain groups transgressed time boundaries. Kelley (1967) discussed the problem further, but concluded that since Bell's nomenclature was well known, it was better to retain it, in spite of its confusion of chronostratigraphic, biostratigraphic and lithostratigraphic terms.

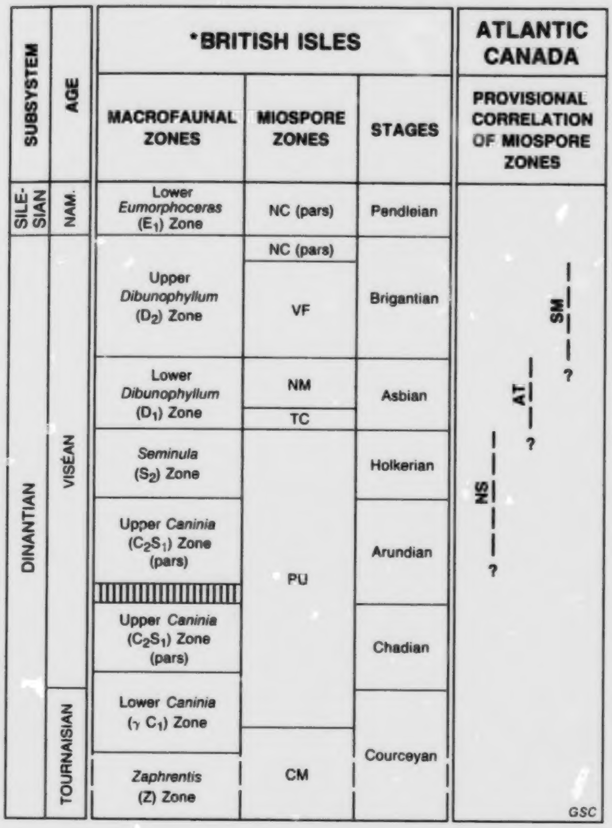
Globensky (1967) studied the conodonts of the Windsor Group and discussed the various possibilities concerning age determinations. He suggested that the assemblages are of 'Middle Mississippian' age or, in terms of the European stages, within the age range from mid-Viséan to early Namurian. Scolecodonts and arenaceous foraminifers of the Windsor Group were studied by Globensky (1968 and 1970, respectively), but the age determinations made were based on data obtained from other fossil groups and from his own work on conodonts (Globensky, 1967).

Mamet (1970) studied the carbonate microfacies of the Windsor Group and proposed a zonation based on foraminifers. Three zones and two subzones were recognized: Zone 15, Zone 16 inférieur, Zone 16 supérieur, and Zone 17. Zone 15 was found to correspond to macrofaunal Subzone B of Bell (1929); Zone 16 inférieur was equivalent to the lower part of Subzone C; Zone 16 supérieur corresponded to the upper part of Subzone C, Subzone D and the basal part of Subzone E; Zone 17 was correlated with the remainder of Subzone E. Mamet considered all of the Windsor subzones proposed by Bell (1929) to be of late Viséan age, with the exception of that part of Subzone E that was placed in Zone 17, and which he considered to be early Namurian. In terms of the stratigraphic division in the United States, Mamet correlated his Zone 15 with the uppermost part of the Meramec; Zone 16 inférieur and supérieur and Zone 17 were correlated with the Chester. He found that Subzone F of Bell (1958) was time equivalent to Subzone E.

Neves and Belt (1970) investigated the palynology of the Canso Group in the Antigonish and southwest Mabou basins. In addition, in the Antigonish basin, they studied two samples from beds which they attributed to the Windsor Group. They assigned a late Viséan age to assemblages from these 'Windsor' samples and to the assemblages from the overlying beds in the lower part of the 'Cansoan' Hastings

TABLE 3

Provisional correlation of concurrent range zones in the British Isles and Atlantic Canada


SUBSYSTEM
AGE
*BRITISH ISLES
MACROFAUNAL ZONES
MIOSPORE ZONES
STAGES
ATLANTIC CANADA
PROVISIONAL CORRELATION OF MIOSPORE ZONES
SILE-SIAN
NAM.
Lower Eumorphoceras (E1) Zone
NC (pars)
Pendleian
DINANTIAN
VISÉAN
NC (pars)
Upper Dibunophyllum (D2) Zone
VF
Brigantian
SM
?
Lower Dibunophyllum (D1) Zone
NM
TC
Asbian
AT
?
Seminula (S2) Zone
Holkerian
NS
?
Upper Caninia (C2S1) Zone (pars)
Arundian
PU
Upper Caninia (C2S1) Zone (pars)
Chadian
TOURNAISIAN
Lower Caninia (γ C1) Zone
Zaphrentis (Z) Zone
CM
Courceyan
GSC

— — — — *Possible range of miospore zones*

*Modified from George et al. (1976), miospore zone information in Neves et al. (1972), Neves et al. (1973) and Clayton et al. (1977)

Note: The boxes representing the macrofaunal and miospore zones and the stages are not drawn to scale. The macrofaunal zones shown are from Derbyshire, Nottinghamshire and Somerset.

Formation; this age was determined by making palynological comparisons with Britain and Northern Spain. The upper part of the Hastings Formation and the lowermost part of the Pomquet Formation they assigned to Namurian A.

Barss and Hacquebard (in Hacquebard, 1972, Fig. 4) summarized the spore zones in the Carboniferous of Eastern Canada. The Horton Bluff and Cheverie formations contained assemblages, which they called 'spore zone g'. This zone contains *Vallatisporites vallatus* Hacquebard and *Spelaeotriletes pretiosus* Playford (Neves and Belt) emend., and was thought to straddle the Tournaisian/Viséan boundary. The Windsor Group is represented by Spore Zone A, which contains *Rugospora* spp. The Windsor Group ranges in age from mid-Viséan to early Namurian (Hacquebard, 1972, Table 1). The early Namurian age is based on the proposal by Mamet (1970). The Canso Group was divided into Spore Zones B/C and D and the group was considered to range in age from late Viséan to late Namurian. Spore Zone B/C contained *Vallatisporites ciliaris* (Luber) Sullivan, *Knoxisporites stephanephorus* Love, and *Grandispora spinosa* Hoffmeister, Staplin and Malloy. Zone D contained *Potonieisporites elegans* (Wilson and Kosanke) Wilson and Venkatachala, *Knoxisporites seniradiatus* Neves, and rare specimens of *Laevigatosporites* spp. Hacquebard pointed out that new data had led to a different interpretation of many of Bell's observations (Bell, 1929, 1944, 1958, 1960). Also, he suggested that the six lithostratigraphic groups of the Carboniferous in Eastern Canada represented a complete record without significant breaks in deposition, whereas Bell considered most of the groups to be bounded by disconformities or unconformities. Hacquebard suggested that from one sub-basin to another, a single group may be of different ages, and different groups may overlap in time and become partly diachronous. This is indicated in Table 1 of Hacquebard (1972) by the zig-zag boundaries.

Howie and Barss (1975) reviewed the biostratigraphic correlation of the Horton, Windsor, and Canso groups and suggested lateral equivalents to these groups in other parts of Eastern Canada. No detailed palynological data were given, although they suggested that the Windsor Group contained two spore zones (Howie and Barss, 1975, p. 42).

Von Bitter (1976) studied the paleoecology and vertical distribution of conodonts from the Windsor Group at Port Hood Island. Most of the species he recorded were from nearshore paleoenvironments (intertidal, lagoonal, and oolite bank). However, one genus, *Gnathodus*, may more typically be an indication of deeper water basinal deposits.

Jansa, Mamet, and Roux (1978) recorded late Viséan foraminifers from limestone of the Newfoundland shelf that are similar to those from the Windsor carbonates in southwestern Newfoundland and Nova Scotia. In addition, they pointed out that the foraminifers belong to the North American realm rather than the Tethyan, and concluded that the proto-Atlantic Sea separated the North American and Euro-African continental blocks in the Early Carboniferous.

Utting (1978) published the results of a palynological study of Windsor Group rocks and Windsor-Canso Group boundary beds in Cape Breton, and, in 1980, gave a summary of the palynological data found in Stewiacke borehole SB-1 in the Shubenacadie Basin of Nova Scotia. It was suggested that there were two assemblage zones in the Windsor Group. Assemblage Zone I coincided with macrofaunal Subzone B and part of Subzone A, and Assemblage Zone II with macrofaunal Subzones C, D, and E. Assemblage Zone III was recognized in the beds at the Windsor-Canso boundary. In the lower part of macrofaunal Subzone A of borehole SB-1, the preservation of the specimens was very poor, but sufficient identifications were made to allow tentative assignment to Assemblage Zone I(?). In addition to typical Windsor Group species, some samples in the lower part of macrofaunal Subzone A contain species more commonly associated with the Horton Group, but it is not certain if these specimens were reworked. Similarities in the spore assemblages from the Windsor Group and the Windsor-Canso boundary beds, and the assemblages from the Viséan of Western Europe described by Clayton et al. (1977), were pointed out by Utting (1978, 1980). Tentative correlations were made with the miospore zones of Western Europe, which had been correlated with the stages proposed by George et al. (1976). The results of the correlations suggest an age for the Windsor Group similar to that proposed originally by Bell (1929). That is to say, the Lower Windsor (Assemblage Zone I) may be correlated with the *Seminula* (S_2) Zone, and the Upper Windsor (Assemblage Zone II) with the Lower *Dibunophyllum* (D_1) Zone. It would appear that the Windsor-Canso boundary material can be correlated with the Upper *Dibunophyllum* (D_2) and Upper *Posidonia* (P_2) zones. Assemblage Zone I(?) could not be correlated with any confidence because of poor preservation, although Utting (1980, Fig. 4) suggests it is one macrofaunal zone older than the *Seminula* (S_2) Zone. George et al. (1976) also suggested possible correlation of the British stages with the stratigraphic units of the United States. If further work confirmed these correlations, the Windsor Group would be equivalent to part of the Meramec, and the Windsor-Canso boundary beds would be equivalent to the latest Meramec and the early Chester.

Von Bitter and Plint-Geberl (1982) gave details of the conodont biostratigraphy of the Codroy Group and recognized four assemblage zones. The *Diplognathodus* Zone from the basal Ship Cove Formation (macrofaunal Subzone A) of the Lower Codroy Group is followed by the *Taphrognathus* Zone, from carbonates above the massive sulphates and thick clastics (lower macrofaunal Subzone B), and the *Cavusgnathus* Zone in the upper part of the Lower Codroy Group (upper macrofaunal Subzone B). The *Gnathodus* Zone (macrofaunal Subzones C, D, and E) occurs in the Upper Codroy Group.

Giles (1981) recognized five major transgressive-regressive cycles within the Windsor Group. He related these cycles to the biostratigraphic data available and proposed a correlation of the cycles with the stages of the British Isles.

Von Bitter and Austin (1984) suggested a correlation between the lower part of macrofaunal Subzone B and the Holkerian Stage of Britain (see Table 3) proposed by George et al. (1976). This correlation was based on a comparison of the *Taphrognathus circumatlanticus* Assemblage Zone in Atlantic Canada and Great Britain. They also suggested a correlation of macrofaunal Subzone B with the middle Viséan (V_2).

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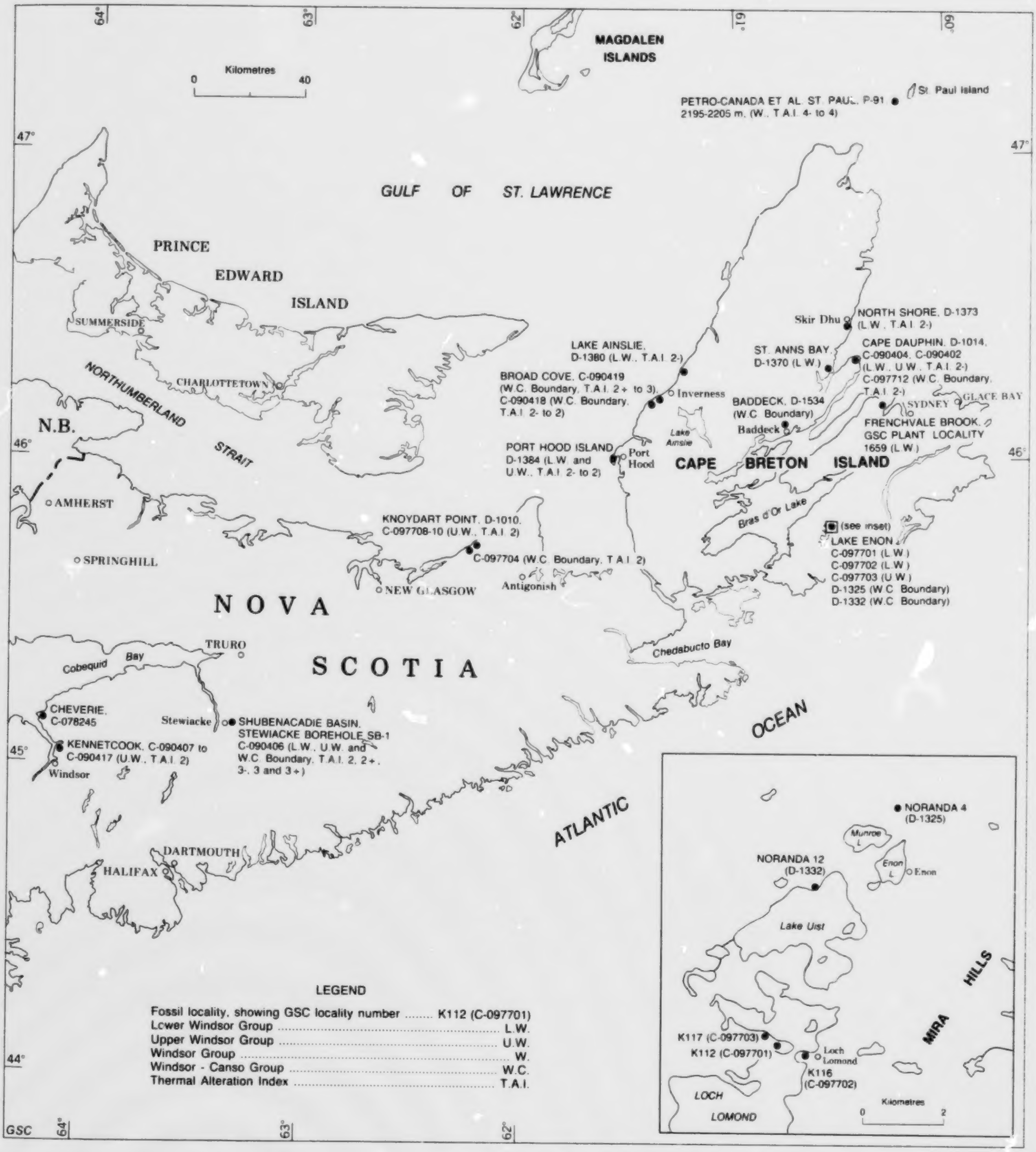
STRATIGRAPHIC PALYNOLOGY

Complete sections of the Windsor Group and its lateral equivalents are rare, as a result of faulting or poor exposure. Samples for palynological studies were taken from numerous sections in four provinces of Atlantic Canada (Nova Scotia, Quebec, Newfoundland and New Brunswick) (see Figures 2-6, Table 4). An attempt was made to obtain these samples from localities where there was some degree of biostratigraphic control (macrofossils and microfossils), or where the relative lithostratigraphic position of beds was known. Of the sections sampled, three were relatively complete and they were all from Nova Scotia. Two of these were outcrops where there was good biostratigraphic control (Port Hood Island and Cape Dauphin sections; see Figure 2), and one was a borehole (Stewiacke SB-1; see Figure 2), the entire length of which was cored.

The qualitative palynological data obtained from all sections studied are given in Appendix 3. The vertical distribution and quantitative distribution of species in two of



64°
63°
62°
61°
60°
MAGDALEN ISLANDS
Kilometres
0
40
PETRO-CANADA ET AL. ST. PAUL P-91
2195-2205 m. (W., T.A.I. 4- to 4)
St. Paul Island
47°
GULF OF ST. LAWRENCE
PRINCE EDWARD ISLAND
SUMMERSIDE
CHARLOTTETOWN
NORTHUMBERLAND STRAIT
N.B.
46°
AMHERST
SPRINGHILL
LAKE AINSLIE,
D-1380 (L.W., T.A.I. 2-)
BROAD COVE, C-090419
(W.C. Boundary, T.A.I. 2+ to 3),
C-090418 (W.C. Boundary,
T.A.I. 2- to 2)
Inverness
Lake Ainslie
PORT HOOD ISLAND
D-1384 (L.W. and
U.W., T.A.I. 2- to 2)
Port Hood
Skir Dhu
NORTH SHORE, D-1373
(L.W., T.A.I. 2-)
ST. ANNS BAY,
D-1370 (L.W.)
CAPE DAUPHIN, D-1014,
C-090404, C-090402
(L.W., U.W., T.A.I. 2-)
C-097712 (W.C. Boundary,
T.A.I. 2-)
SYDNEY
GLACE BAY
BADDECK, D-1534
(W.C. Boundary)
Baddeck
FRENCHVALE BROOK,
GSC PLANT LOCALITY
1659 (L.W.)
CAPE BRETON ISLAND
Bras d'Or Lake
(see inset)
LAKE ENON
C-097701 (L.W.)
C-097702 (L.W.)
C-097703 (U.W.)
D-1325 (W.C. Boundary)
D-1332 (W.C. Boundary)
KNOYDART POINT, D-1010,
C-097708-10 (U.W., T.A.I. 2)
C-097704 (W.C. Boundary, T.A.I. 2)
Antigonish
NEW GLASGOW
NOVA SCOTIA
TRURO
Cobequid Bay
Chedabucto Bay
CHEVERIE,
C-078245
Stewiacke
SHUBENACADIE BASIN,
STEWIACKE BOREHOLE SB-1
C-090406 (L.W., U.W. and
W.C. Boundary, T.A.I. 2, 2+,
3-, 3 and 3+)
45°
KENNETCOOK, C-090407 to
C-090417 (U.W., T.A.I. 2)
Windsor
OCEAN
ATLANTIC
DARTMOUTH
HALIFAX
44°
LEGEND
Fossil locality, showing GSC locality number K112 (C-097701)
Lower Windsor Group .... L.W.
Upper Windsor Group .... U.W.
Windsor Group .... W.
Windsor - Canso Group .... W.C.
Thermal Alteration Index .... T.A.I.
NORANDA 4
(D-1325)
Munroe L
Enon L
Enon
NORANDA 12
(D-1332)
Lake Uist
MIRA HILLS
K117 (C-097703)
K112 (C-097701)
Loch Lomond
K116
(C-097702)
LOCH LOMOND
Kilometres
0
2
GSC

Figure 2. *Sample localities and Thermal Alteration Indices in Nova Scotia.*

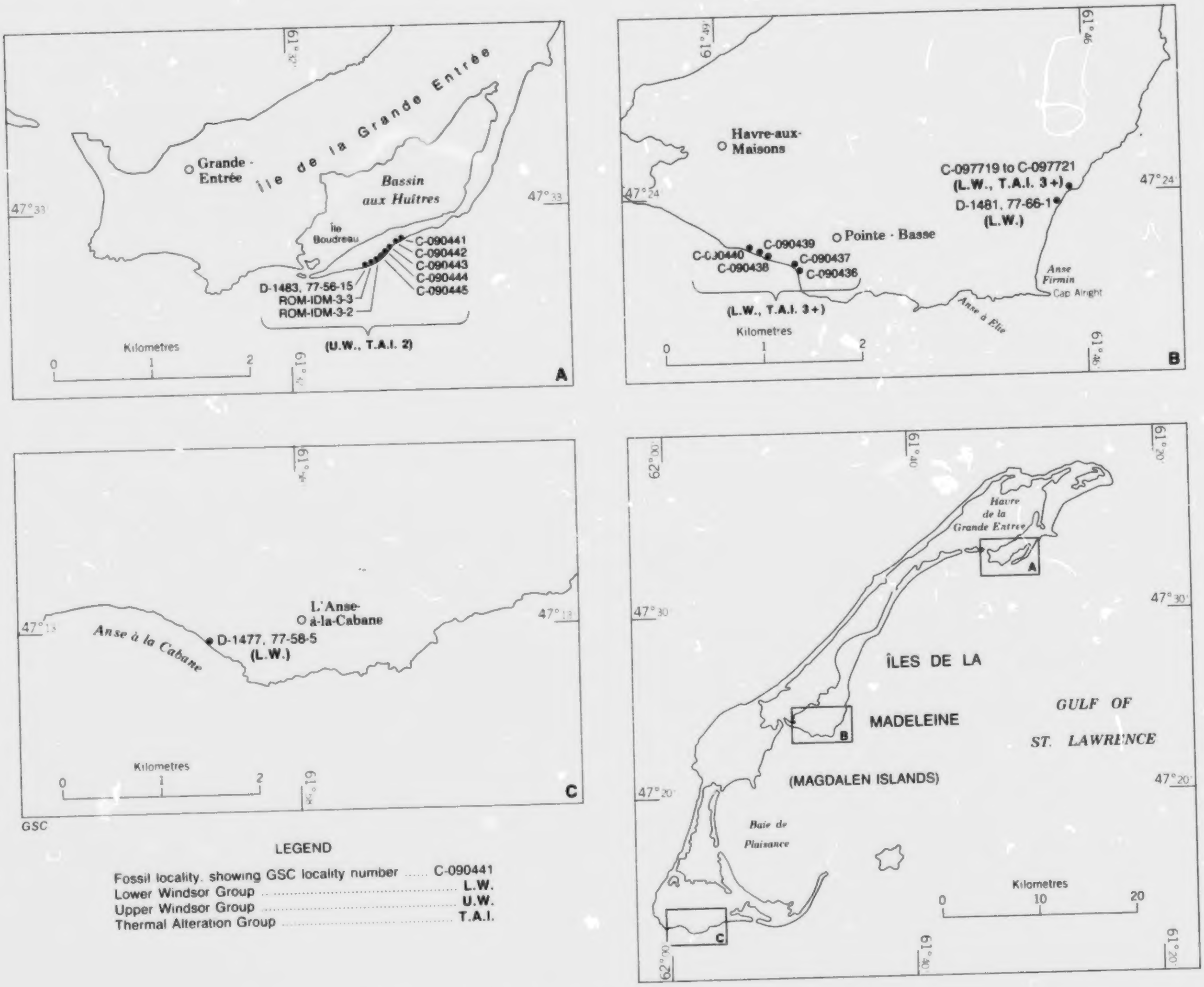

Grande-Entrée
Île de la Grande Entrée
Bassin aux Huîtres
Île Boudreau
C-090441
C-090442
C-090443
C-090444
C-090445
D-1483, 77-56-15
ROM-IDM-3-3
ROM-IDM-3-2
(U.W., T.A.I. 2)
Kilometres
0
1
2
47°33′
61°42′
A
Havre-aux-Maisons
Pointe - Basse
C-097719 to C-097721
(L.W., T.A.I. 3+)
D-1481, 77-66-1
(L.W.)
C-090440
C-090439
C-090438
C-090437
C-090436
(L.W., T.A.I. 3+)
Anse Firmin
Cap Alright
Anse à Elie
47°24′
61°49′
61°46′
B
L'Anse-à-la-Cabane
Anse à la Cabane
D-1477, 77-58-5
(L.W.)
47°13′
61°54′
C
GSC
LEGEND
Fossil locality, showing GSC locality number C-090441
Lower Windsor Group ...... L.W.
Upper Windsor Group ...... U.W.
Thermal Alteration Group ...... T.A.I.
Havre de la Grande Entrée
ÎLES DE LA MADELEINE
(MAGDALEN ISLANDS)
GULF OF ST. LAWRENCE
Baie de Plaisance
62°00′
61°40′
61°30′
61°20′
47°30′
47°20′

Figure 3. Sample localities and Thermal Alteration Indices in Quebec.

the relatively complete sections are shown in Figures 7 to 10. In addition, quantitative data from selected localities are shown in Figure 10. In the following pages, the qualitative nature of the assemblages is first discussed and this is followed by a summary of the quantitative data.

Qualitative analysis of samples

Compilation of the palynological data from all the sources outlined above suggests that concurrent range zones for the Windsor Group and its lateral equivalents in Atlantic Canada may be formally recognized. These range zones are defined in the sense used by the Report of the Stratigraphical Code Subcommittee of the Geological Society of London (1967, p. 85). In cases where two species have been used to name the zone, the initials of each species may be given as a convenient reference, and where only one species is selected then the first two letters may be used. The proposed concurrent range zones are:

i) *Lycospora noctuina* var. *noctuina* - *Knoxisporites stephanephorus* (NS) Zone. Both *Lycospora noctuina* Butterworth and Williams var. *noctuina* and *Knoxisporites stephanephorus* first appear in the Windsor Group and have not been recorded from the underlying Horton Group

ii) *Schopfipollenites acadiensis* - *Knoxisporites triradiatus* (AT) Zone

iii) *Grandispora spinosa* - *Ibrahimispores magnificus* (SM) Zone

TABLE 4

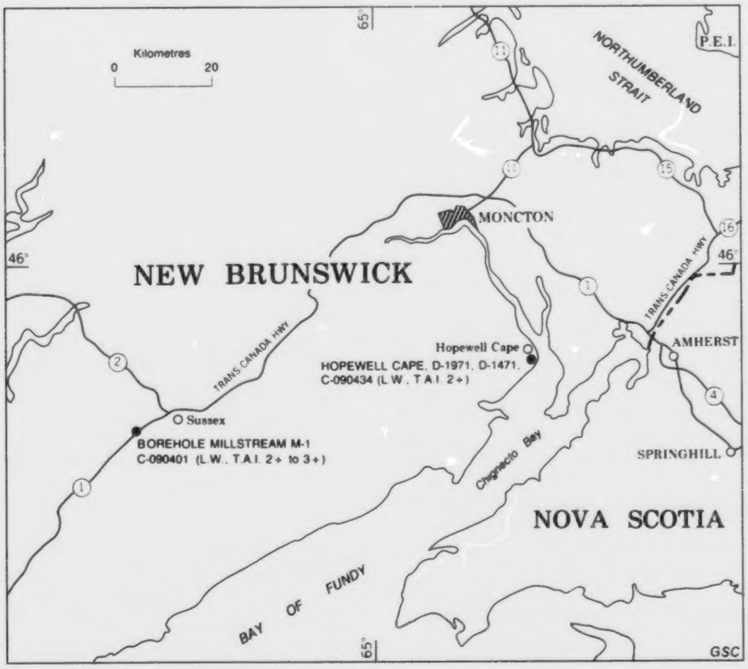
Stratigraphic units from which samples in southwestern Newfoundland were collected

GROUP	FORMATION	LOCALITIES AND SAMPLE NUMBERS			
BARACHOIS	*SEARSTON*	Cape Cove^{12} C-097717 C-090450	Kennedy Point^{13} C-097718, C-090446 C-090447, C-090448		
CODROY	*WOODY CAPE*	Woody Cape^{10} C-090426 C-090427 C-090428 C-090429 C-090430	Capelin Cove^{11} C-090431 C-090432		
	ROBINSONS RIVER (Mollichignick Member)	Heatherton^{5} Heath-2-9*	Grand Codroy River^{6} C-090420 C-090421 C-090422 C-090423 C-090424 C-090425		
	CODROY ROAD	Codroy/Woodville^{8} C-097731 C-097732 C-097733 C-097734	south of Woodville^{9} C-097735 C-097736 C-097737		
	SHIP COVE	Boswarlos^{1} Bos-1-5* Bos-1-3* Bos-1-2* Bos-1-1* Aguathuna^{2} Agu-1-2* Agu-1-1*	Romaines Brook^{3} Rom-1-3* Rom-1-2*	Fischells Brook^{4} Shp-Cv-4-3* Shp-Cv-4-2* Shp-Cv-Sp-2* Shp-Cv-Sp-1* Shp-Cv-4-1*	Codroy Island^{7} C-097738
ANGUILLE					

GSC

*Royal Ontario Museum curation numbers

Note: Superscripts $^{1-13}$ refer to sample localities shown on accompanying map (Figure 6)


Kilometres
0
20
65°
P.E.I.
NORTHUMBERLAND STRAIT
11
15
16
MONCTON
46°
46°
NEW BRUNSWICK
1
TRANS CANADA HWY
TRANS CANADA HWY
AMHERST
Hopewell Cape
HOPEWELL CAPE, D-1971, D-1471, C-090434 (L.W., T.A.I. 2+)
2
Sussex
BOREHOLE MILLSTREAM M-1 C-090401 (L.W., T.A.I. 2+ to 3+)
4
SPRINGHILL
Chignecto Bay
NOVA SCOTIA
BAY OF FUNDY
65°
GSC

LEGEND

Fossil locality, showing GSC locality number	C-090401
Lower Windsor Group	L.W.
Upper Windsor Group	U.W.
Windsor Group	W.
Thermal Alteration Index	T.A.I.

Figure 4. *Sample localities and Thermal Alteration Indices in New Brunswick.*

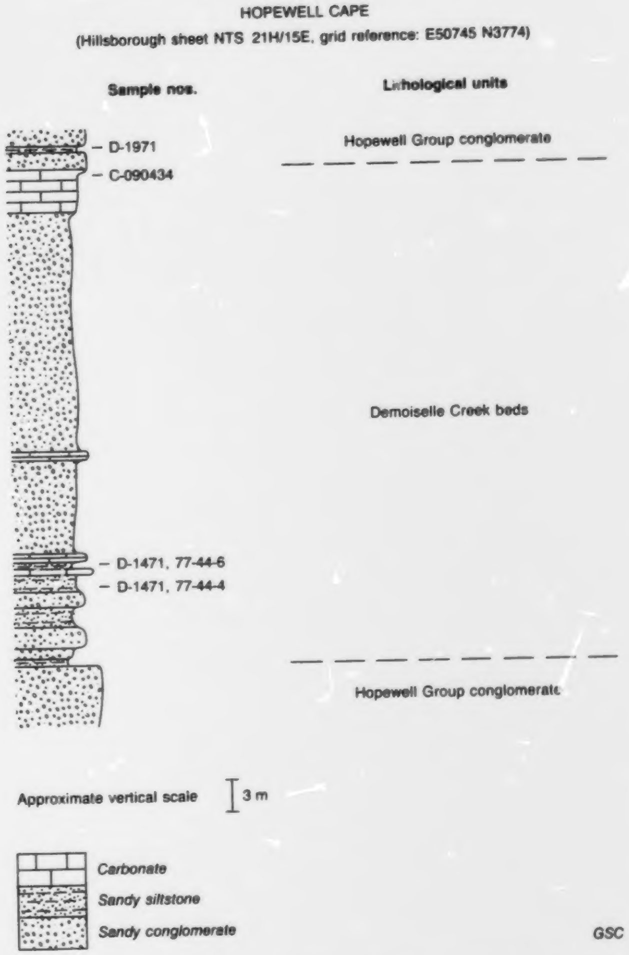


Figure 5. *Stratigraphic section at Hopewell Cape, New Brunswick.*

These zones correspond to the informal nomenclature given by Utting (1978 and 1980), in that Assemblage Zone I corresponds to the NS Zone, Assemblage Zone II to the AT Zone and Assemblage Zone III to the SM Zone. In these previous publications (*ibid.*), assemblage zones were used either because relatively few sections had been investigated (Utting, 1978), or they concerned only one borehole (Utting, 1980). Now that the stratigraphic ranges of species are known from a number of sections, it is believed that the use of concurrent range zones is more appropriate. This proposal is made with some reservations, because, as discussed later under "Paleontological implications", the Windsor Group, and its lateral equivalents in Atlantic Canada, were deposited in an area that was structurally enclosed, and the climate was hot and dry. This produced a palynoflora of limited variety that persisted through time. As a result, the number of species that have their first appearance in time are limited and the number of specimens is generally rare. Table 5 is a composite list of species present in each zone, and in Table 6 those species that are of stratigraphic and zonal significance are listed, as well as their relative abundances. The palynological characteristics of the relatively complete sections are summarized below; the less complete sections are discussed in Appendix 3.

TABLE 5

Composite list of species present in the respective concurrent range zones

SPECIES RECORDED	CONCURRENT RANGE ZONES		
	NS	AT	SM
Discernisporites macromanifestus	(x)?		
Elektoriskos sp. A	x		
Leiosphaeridia? sp. A	x		
Vallatisporites verrucosus	x		
Auroraspora solisortus	x	x	
Chomotriletes multivittatus	x	x	
Densosporites columbaris	x	x	
Discernisporites barssii	x	x	
Discernisporites diaphanes	x	x	
Eisenackidium playfordii	x	x	
Knoxisporites literatus	x	x	
Leiosphaeridia? scotia	x	x	
Lycospora pusilla "tendance B2"	x	x	
Microreticulatisporites hacquebardii	x	x	
Neoraistrickia versiforma	x	x	
Raistrickia clavata	x	x	
Scutulum trisupplementum	x	x	
Spelaeotriletes echinatus	x	x	
Spelaeotriletes tuberosus	x	x	
Verrucosisporites verrucosus	x	x	
Acanthotriletes hacquebardii	x	x	x
Anapiculatisporites fundiensis	x	x	x
Biannulatisporites simplex	x	x	x
Auroraspora macra	x	x	x
Calamospora parva	x	x	x
Colatisporites decorus	x	x	x
Convolutispora labyrinthea	x	x	x
Convolutispora mellita	x	x	x
Convolutispora tessellata	x	x	x
Convolutispora vermiformis	x	x	x
Crassispora trychera	x	x	x
Cristatisporites submarginatus	x	x	x
Dictyotriletes odontolophos	x	x	x
Discernisporites micromanifestus	x	x	x
Grandispora uncata	x	x	x
Granulatisporites tuberculatus	x	x	x
Knoxisporites probolos	x	x	x
Knoxisporites stephanephorus	x	x	x
Leiotriletes inermis	x	x	x
Leiotriletes ornatus	x	x	x
Lycospora noctuina var. *noctuina*	x	x	x
Punctatisporites irrasus	x	x	x
Puctatisporites minutus	x	x	x
Punctatisporites planus	x	x	x
Pustulatisporites multicapitis	x	x	x
Raistrickia baculosa	x	x	x
Raistrickia magdalena	x	x	x
Retusotriletes incohatus	x	x	x
Rugospora minuta	x	x	x
Rugospora polyptycha	x	x	x
Schopfites claviger	x	x	x
Spelaeotriletes pretiosus var. *bellii*	x	x	x
Spelaeotriletes pretiosus var. *windsorensis*	x	x	x
Vallatisporites ciliaris	x	x	x
Verrucosisporites morulatus	x	x	x
Verrucosisporites nitidus	x	x	x
Verrucosisporites papulosus	x	x	x
Actinotodissus sp. A		x	
Granulatisporites sp. cf. *G. tuberculatus*		x	
Knoxisporites sp. A		x	
Knoxisporites triradiatus		x	x
Micrhystridium sp.		x	x
Rugospora corporata var. *verrucosa*		x	x
Schopfipollenites acadiensis		x	x
Secarisporites remotus			x
Grandispora spinosa			x
Ibrahimispores magnificus			x
Raistrickia nigra			x
Schulzospora bilunata			x
Secarisporites lobatus			x
Tricidarisporites arcuatus			x

GSC

LEGEND

NS - *Lycospora noctuina* var. *noctuina-Knoxisporites stephanephorus* Zone
AT - *Schopfipollenites acadiensis-Knoxisporites triradiatus* Zone
SM - *Grandispora spinosa-Ibrahimispores magnificus* Zone
x - species present
(x)? - species present but possibly reworked

i) *Lycospora noctuina* var. *noctuina* - *Knoxisporites stephanephorus* (NS) Zone:

Assemblages typical of this zone occur in the following beds:

a) Port Hood Island section, GSC locality D-1384, from 0 m to 298 m above the base of the outcrop (see Figures 7 [in pocket], 8 and Appendix 3 - Nova Scotia section A, a). Stacy (1953) assigned this interval to the macrofaunal Subzone B of Bell (1929).

b) Stewiacke borehole SB-1, GSC locality C-097715, from 325.5 m to 677.0 m from the top of the borehole (see Figures 9 [in pocket], 10 and Appendix 3 - Nova Scotia section B, a).

c) Cape Dauphin section, from 0 m to 9.1 m above the base of the outcrop (GSC locs. D-1014 and C-090404, see Figure 10, and Appendix 3 - Nova Scotia section A, c). Stacy (1953) assigned this part of the section to the macrofaunal Subzone B of Bell (1929).

Species characteristic of this zone are listed in Tables 5 and 6. In general the assemblages are lacking in diversity and are dominated by relatively few species. (*Crassispora trychera*, *Rugospora minuta*, *Punctatisporites planus* and *Retusotriletes incohatus*).

ii) *Schopfipollenites acadiensis* - *Knoxisporites triradiatus* (AT) Zone:

Assemblages of this zone are typically represented in the following beds:

a) Port Hood Island section, from 315 m to 566 m above the base (GSC loc. D-1384). This interval was assigned by Stacy (1953) to macrofaunal Subzones C and D (see Figure 7 [in pocket], 8 and Appendix 3, Nova Scotia section A, a).

b) Stewiacke borehole SB-1, GSC locality C-097715, from 189.28 m to 325.22 m from the top of the borehole (see Figure 9 [in pocket], 10 and Appendix 3, Nova Scotia section B, a).

c) Cape Dauphin section, GSC locality D-1014 and C-090402 (see Figure 10 and Appendix 3, Nova Scotia section A, c). The samples studied came from the upper part of the unit assigned by Stacy (1953, p. 37) to the macrofaunal Subzone D of Bell (1929), and from the base of macrofaunal Subzone E.

The characteristic species of this zone are shown in Tables 5 and 6. Most of the species present in the NS Zone continue into the AT Zone, but a number of species make their first appearance in the AT Zone. These include *Knoxisporites triradiatus*, *Raistrickia magdalena*, *Rugospora corporata* var. *verrucosa* and *Schopfipollenites acadiensis*.

TABLE 6

Species considered to be of stratigraphic and zonal significance

LITHOSTRATIGRAPHIC UNIT	MACROFAUNAL ZONE	MIOSPORE ZONES	**First appearance of selected species**	**Species occurring abundantly in zone**
CANSO GROUP		not assigned	*Potonieisporites elegans** (R)	
?		?		
BOUNDARY BEDS		SM	*Grandispora spinosa* (R) *Ibrahimispores magnificus* (R) *Raistrickia nigra* (R) *Schulzospora bilunata* (R) *Tricidarisporites arcuatus* (R)	*Crassispora trychera*
?				
WINDSOR GROUP	E D C	AT	*Knoxisporites triradiatus* (R) *Rugospora corporata* var. *verrucosa* (R) *Schopfipollenites acadiensis* (R)	*Crassispora trychera* *Rugospora minuta*
	B A	NS	*Densosporites columbaris* (R) *Knoxisporites probolos* (R) *Knoxisporites stephanephorus* (C) *Lycospora noctuina* var. *noctuina* (C) *Lycospora pusilla* ''tendance B2'' (R) *Spelaeotriletes tuberosus* (R)	*Crassispora trychera* *Rugospora minuta*

GSC

*Information from Neves and Belt (1971)

(R) = rare (C) = common

iii) *Grandispora spinosa* - *Ibrahimispores magnificus* (SM) Zone.

This zone includes sediments that occur at the Windsor-Canso Group boundary, in the lower beds where the contact between the two groups may be arbitrary. It was recorded in the following sections:

a) Stewiacke borehole SB-1 (GSC loc. C-097715) in the interval from 51.0 m to 120.0 m. This is part of the "Watering Brook formation" of Giles and Boehner (1979) (see Figures 9 [in pocket], 10 and Appendix 3, Nova Scotia section B, a).

b) Cape Dauphin section (GSC loc. C-097712) in the interval approximately 5.5 m above the uppermost carbonate unit of the Windsor Group (see Figure 10 and Appendix 3, Nova Scotia section A, c).

The characteristic species of this zone are listed in Tables 5 and 6. Species that first appear in the zone include: *Grandispora spinosa*, *Ibrahimispores magnificus*, *Raistrickia nigra*, *Schulzospora bilunata*, and *Tricidarisporites arcuatus*.

The palynology of the beds overlying the Windsor-Canso boundary, and their lateral equivalents, has not been studied in detail. Occasional samples, for example, from the Searston Formation, Barachois Group, S.W. Newfoundland

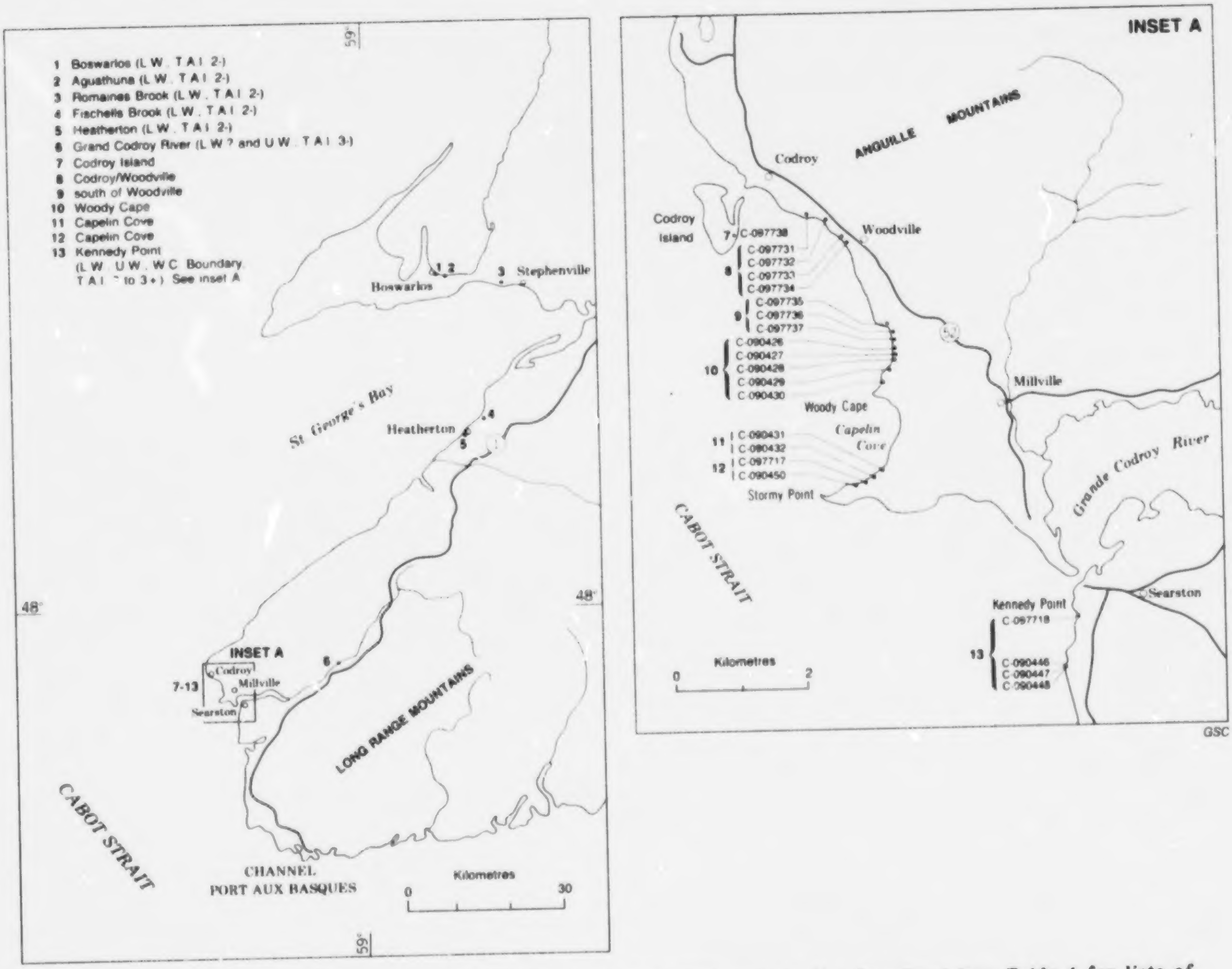

1 Boswarlos (L.W., T.A.I. 2-)
2 Aguathuna (L.W., T.A.I. 2-)
3 Romaines Brook (L.W., T.A.I. 2-)
4 Fischells Brook (L.W., T.A.I. 2-)
5 Heatherton (L.W., T.A.I. 2-)
6 Grand Codroy River (L.W.? and U.W., T.A.I. 3-)
7 Codroy Island
8 Codroy/Woodville
9 south of Woodville
10 Woody Cape
11 Capelin Cove
12 Capelin Cove
13 Kennedy Point (L.W., U.W., W.C. Boundary, T.A.I. ? to 3+) See inset A
59°
48°
Boswarlos
Stephenville
St. George's Bay
Heatherton
INSET A
Codroy
Millville
Searston
7-13
LONG RANGE MOUNTAINS
CABOT STRAIT
CHANNEL PORT AUX BASQUES
Kilometres
0
30
INSET A
ANGUILLE MOUNTAINS
Codroy
Codroy Island
Woodville
7 C-097730
8 C-097731 C-097732 C-097733 C-097734
9 C-097735 C-097736 C-097737
10 C-090426 C-090427 C-090428 C-090429 C-090430
Woody Cape
Capelin Cove
11 C-090431 C-090432
12 C-097717 C-090450
Stormy Point
Millville
Grande Codroy River
CABOT STRAIT
Kennedy Point
13 C-097718 C-090446 C-090447 C-090448
Searston
Kilometres
0
2
GSC

Figure 6. *Sample localities and Thermal Alteration Indices in southwestern Newfoundland (see Table 4 for lists of sample numbers).*

(Appendix 3, section F), are known to contain *Potonieisporites elegans* (Wilson and Kosanke) Wilson and Venkatachala and *Granulatisporites granulatus* Ibrahim. The appearance of *Potonieisporites elegans* has been used in this paper to define the beginning of the Namurian; this species appears at the base of the E_1 Goniatite Zone in Western Europe (Clayton et al., 1977).

Quantitative analysis of samples

Quantitative data concerning selected samples from outcrop and subsurface sections are shown in Figures 8 and 10. The outcrop samples are from the Port Hood Island section, Cape Breton Island (macrofaunal Subzones B, C and D), the Cape Dauphin section, Cape Breton Island (macrofaunal Subzones B and D, and the Windsor/Canso Group boundary beds (see Appendix 3, Nova Scotia section A, c); two selected samples are from the Ship Cove Formation, Codroy Group, Newfoundland (macrofaunal Subzone A. See Appendix 3 - S.W. Newfoundland sections A, a and A, c). The subsurface samples are from Stewiacke borehole SB-1, Nova Scotia (macrofaunal Subzones A, B, C, D, and E, and the Windsor/Canso Group boundary beds.

The counts shown in Figures 8 and 10 represent the actual number of specimens of each species seen in each sample during a series of random traverses. Slides used were those prepared from coarse fractions greater than 20 µm. Thus, it is possible that the counts of very small forms, such as *Punctatisporites minutus*, may be artificially low, although the fine fractions were checked and it appeared that very few specimens of any miospore species passed through the sieve. Those that did were of insufficient number to alter the general quantitative trends significantly.

The quantitative data indicate that almost all of the samples from the Windsor Group are similar, being dominated by *Crassispora trychera* and *Rugospora minuta*; common (more than 20 specimens) are *Retusotriletes incohatus* and *Punctatisporites planus*. In some samples, *Auroraspora macra*, *Convolutispora labyrinthea*, *Punctatisporites irrasus* and *Schopfites claviger* are common. *Spelaeotriletes* *pretiosus* var. *windsorensis* is common in some samples from the AT Zone. In the Windsor/Canso Group boundary beds, the main quantitative change is that *Crassispora trychera* alone dominates the assemblage. In certain samples, *Lycospora noctuina* var. *noctuina*, *Knoxisporites triradiatus*, *Rugospora minuta* and *Schopfipollenites acadiensis* are common.

A further characteristic of the assemblages, evident from the quantitative data, is that the stratigraphically diagnostic species used to distinguish the zones are rare (see Table 6). For example, in the Port Hood Island section (see Figure 8), the number of specimens of *Schopfipollenites acadiensis* in the AT Zone is very low, and in some poor assemblages no specimens were seen. Similarly, *Knoxisporites triradiatus* and *Rugospora corporata* var. *verrucosa* were not seen in every sample, and when they were present they were rare. In the SM Zone, the stratigraphically significant species, *Grandispora spinosa*, *Ibrahimispores magnificus* and *Schulzospora bilunata*, are rare.

Thus the zonal scheme presented in this paper is based by necessity on the first appearance of certain rare, stratigraphically diagnostic species. The majority of species in the assemblages have a vertical distribution, which extends throughout the Windsor Group and the Windsor-Canso Group boundary beds and their lateral equivalents. Therefore, it must be stressed that only suites of productive samples can reliably be assigned to the spore zones proposed here, and that the dating of single samples may prove to be impossible.

Comparison and age of spore assemblages

As outlined in a previous publication (Utting, 1980), the assemblages from the Windsor Group resemble those from Western Europe more than any other place from which data are so far available. There are certain species in common with Western Canada and the Arctic Islands, but in general the assemblages are different (Utting, 1982). Lower Carboniferous assemblages of Western Canada and the Arctic Islands are generally similar to those from Spitsbergen described by Playford (1962, 1963). Many of the variations between Lower Carboniferous assemblages of Atlantic Canada and those of Western Canada and the Arctic Islands can be explained in terms of regional differentiation of floras, such as proposed by Sullivan (1965) and Van der Zwan (1981). The Lower Carboniferous of Atlantic Canada may be assigned to the *Vallatisporites* Region of Van der Zwan (1981), which included the subtropical dry belt of south Euramerica, extending from eastern Canada through Ireland, Great Britain, and Denmark.

a) Western Europe

In the following section, an attempt at correlation with the Viséan of Western Europe is made. At the type section in Belgium, the stage is subdivided into V_I , V_{II} and V_{III} , or V_1, V_2 and V_3 (Paproth et al., 1983). The latter symbols are more commonly used in the literature and are employed here. This use is in preference to the informal designation of lower middle and upper Viséan. It should be stressed, however, that recognition of Viséan V_1, V_2 and V_3 requires good faunal control and cannot, at the present time, be established from the palynological data alone. Correlations are suggested below, but they may require emendation as further studies are carried out on the marine faunas.

Table 7 compares the assemblages of Atlantic Canada with those from Western Europe; the data for the latter are from Clayton et al. (1977). In Table 3, a provisional correlation of concurrent range zones in the British Isles and Atlantic Canada is suggested, and the macrofaunal zones and stages of the British Isles are shown. Table 7 shows that there are many similarities between the NS, AT, and even the SM zones, and the *Schopfites claviger* - *Auroraspora macra* (CM) Zone of Western Europe. Species which they have in common include: *Auroraspora macra*, *Crassispora trychera*, *Raistrickia clavata*, *Retusotriletes incohatus*, *Schopfites claviger*, *Spelaeotriletes pretiosus* and *Verrucosisporites nitidus*. However, all of these species, with the exception of *R. clavata*, were shown by Clayton et al. (1977) to extend into the younger *Lycospora pusilla* Pu Zone of Western Europe, where species of *Lycospora* first appear. In the NS Zone, *Lycospora pusilla* and *Lycospora noctuina* occur, thus suggesting an age no older than the Pu Zone. The presence of *Knoxisporites stephanephorus* and *Vallatisporites ciliaris* in the NS Zone may also prove significant; for example, Neves et al. (1972) recorded these two specimens as appearing in the upper part of the Pu Zone. Thus, at present it would seem reasonable to correlate the NS Zone with the upper part of the Pu Zone. Clayton et al. (1977) indicated that the Pu Zone ranged from latest Tournaisian (Tn3) through the Viséan (V_1 and V_2) to the earliest part of V_3. Thus, correlation with the upper part of the Pu Zone may indicate a V_2, or earliest V_3, age and imply a correlation with the Arundian(?) to Holkerian stages of Britain (Table 3).

Correlation of the AT Zone is also speculative; the significance of the appearance of *Knoxisporites triradiatus*, *Rugospora corporata* var. *verrucosa* and *Schopfipollenites acadiensis* in the AT Zone is not clear. *Knoxisporites triradiatus* was recorded by Clayton et al. (1977) as occurring in the VF Zone, which they suggested was of Viséan (V_3) age. Neville (1968) recorded *Rugospora corporata* var. *verrucosa* from samples just below the base of the P_1 Goniatite Zone up to beds thought to be close to the boundary of the P_2 and E_1 zones. In terms of the stages proposed by George et al. (1976), the base of P_1 is in the uppermost part of the Asbian, with the remainder of the zone in the Brigantian. P_2 is in the upper part of the Brigantian and E_1 is in the lower Pendleian. *Schopfipollenites ellipsoides* (Ibrahim) Potonié and Kremp, a species closely related to *S. acadiensis*, was shown by Neves et al. (1972) to appear at the base of the *Bellispores nitidus* - *Reticulatisporites carnosus* (NC) Zone, which they correlated with the upper part of the P_2 of late Viséan age. Thus, it is probable that the AT Zone of Atlantic Canada is late Viséan in age. However, the more precise, albeit tentative, correlation (Table 3) with the *Perotrilites tessellatus* – *Schulzospora campyloptera* (TC) Zone and the *Raistrickia nigra* – *Triquitrites marginatus* (NM) Zone, is less certain. It relies more on the relative stratigraphic position of the AT Zone than on the presence of stratigraphically significant species. On the other hand, the fact that *Rugospora corporata* var. *verrucosa*, appears in Britain in the Asbian lends some support to the proposed correlation.

In the SM Zone, the species *Grandispora spinosa*, *Ibrahimispores magnificus*, *Raistrickia nigra*, *Tricidarisporites arcuatus* and *Schulzospora bilunata* appear. *Raistrickia nigra* and species of *Schulzospora* appear in Western Europe in the *Raistrickia nigra* – *Triquitrites marginatus* (NM) Zone. On the other hand, *Grandispora spinosa* does not appear in Europe until the *Tripartites vetustus* – *Rotaspora fracta* (VF) Zone. *Tricidarisporites arcuatus* was recorded by Neves et al. (1973) in the TC, NM and VF zones. The precise stratigraphic range of *Ibrahimispores magnificus* is not known. Neves (1961) recorded this species from rocks of Namurian C age in

LITHOSTRATIGRAPHIC UNIT	MACROFAUNAL SUBZONE	CONCURRENT RANGE ZONE	SAMPLE NUMBERS	SPECIES RECORDED																																																								Total number of specimens
				Actinotodissus sp. A	*Anapiculatisporites fundiensis*	*Auroraspora macra*	*Auroraspora solisortus*	*Biannulatisporites simplex*	*Calamospora parva*	*Chomotriletes multivittatus*	*Colatisporites decorus*	*Convolutispora labyrinthea*	*Convolutispora mellita*	*Convolutispora tessellata*	*Convolutispora vermiformis*	*Crassispora trychera*	*Cristatisporites submarginatus*	*Densosporites columbaris*	*Dictyotriletes odontolophos*	*Discernisporites barssii*	*Discernisporites diaphanes*	*Discernisporites micromanifestus*	*Eisenackidium playfordii*	*Grandispora uncata*	*Granulatisporites tuberculatus*	*Knoxisporites literatus*	*Knoxisporites probolos*	*Knoxisporites stephanephorus*	*Knoxisporites triradiatus*	*Knoxisporites* sp. A	*Leiosphaeridia*? *scotia*	*Leiosphaeridia*? sp. A	*Leiotriletes inermis*	*Leiotriletes ornatus*	*Lycospora noctuina* var. *noctuina*	*Lycospora pusilla* "tendance B2"	*Microreticulatisporites hacquebardii*	*Neoraistrickia versiforma*	*Punctatisporites irrasus*	*Punctatisporites minutus*	*Punctatisporites planus*	*Pustulatisporites multicapitis*	*Raistrickia clavata*	*Raistrickia magdalena*	*Retusotriletes incohatus*	*Rugospora corporata* var. *verrucosa*	*Rugospora minuta*	*Rugospora polyptycha*	*Schopfipollenites acadiensis*	*Schopfites claviger*	*Scutulum trisupplementum*	*Secarisporites remotus*	*Spelaeotriletes echinatus*	*Spelaeotriletes pretiosus* var. *bellii*	*Spelaeotriletes pretiosus* var. *windsorensis*	*Spelaeotriletes tuberosus*	*Vallatisporites ciliaris*	*Verrucosisporites morulatus*	*Verrucosisporites nitidus*	*Verrucosisporites papulosus*	*Verrucosisporites verrucosus*	
UPPER WINDSOR	E	AT	E₁																																									1		1																2
	D		34									1	1	1	1	9									2		1	1	1								1							1	1		2	1	1	2				1								28
			33			3		1		1	1	1			1	36		1						1													1		1	1					3		6	1	3	6				1	4	1				1		75
			32	1						1				1		35						1					1							1	1		1			1				1	1		16		1	8				1								72
			31									1			1	24																			3		1			1				1	2		6		2	6					1			1	1			51
			30			1						2		1		1											1							1	1										1		1		1	1												12
			29			1	2		1		1	2	2	1	2	7	1		1		1		1		1					1				1	2						4		1		6	1	9		1	7				1	8	1			1			68
			28			1	1		1			1			1	10					1					1	1		1					1					1		2				2		23	1	2	2					4			1				58
			27			2	1				1	1	1	1	1	17					1						1	1						1					1		1			1	1		23	1	2	2	2			1	1				1			66
			26									4	1	1		8											1		1					1	1		1		4		10				1		1		1	1					1			1	1			40
			25									4		1		1	1										1		1						1		1		1		1				1		1		1	2		1		1	1				1			23
			24													1																													1					1												3
			23			1						1		1		24			1	1		4			1									1	1				3		1				14		20		2	2				1	1	1						81
			22			1	3		1			2	1	1	2	19				1	1	1			1		1							1	1				1	1		1			3		55	1	1	5	1			1	1			2				110
	C		21			1				1	1	4		2	1	13									1		1	1						1	2				1	2	8		1		2		8		1	2				1	1			2				58
			20									3		1		28						1												1							5				20	1	40	1		1				1	1			2	1			107
			19			1						2				13						1			1			1							1						1				9		14		4	3												51
			18									1		1		31					1				1			1							1				1	3					4		16			1				1								63
			17			1						5				15						1					1				1			1	1		1		1	1	2	1		1	16		29	2	1	3			1		1				1			87
			16		1		1		1			4				30	1		1		1	2					1	1						1	6		1			1	3	1		1	2	1	66	1	1	2	1			1	3			1				137
			15			1						9		1		36					1	1			1		1		1						2				3	1	6				19		13	3	1					1	1	1		1	1			105
			C₂											1		1																													1		1		1	1												6
			14			5	4		1		1	4	2	2	1	20	1	1		1	1				1									1					3	1	3		1		4	1	21	1	1	1				1	1	1		1	1			88
			C₁			1										1																								1	1				1		1		1	1								1				9
LOWER WINDSOR	B	NS	13									1		1	1	12			1			1						1													5				21		40			1				1				1	2			89
			12			6					1	1		1		38						1			1			1					1						8	1					9		20						3	1				1				94
			11		1	8	1		1		1					33					1										1	1							2		6				18		21	1		2			1	1		1		1				102
			10			4	1				1	1		1		26						1			1									1	1			1	1	1	2				2		29			2	1							1		1		79
			9			1	1				1	2		1		15					1	1												1							2				3		28							1		1		1	1			61
			8				1		1			2		1		12						1			1								1	1					8	1					4		33			1				1				1	1			71
			7		2	2		1	1		1	3		1		42			1	1	1	1	1		1						1	1	1	1	2				2	3	2				8		26			8			2	1		1		4	4			126
			6		1	1	2		1		1				1	35			2		1	1				1							1	1				1	1		1				5		7	2		1	1			1		1		2			1	73
			5			3					1	1				14																			1				1	1	4				10		16	1														53
			4																																																											0
			3		4	2			1		1	10		1	1	14	1					1			1	1		1			1		1	1	2	1	1		2		3				2		8	1		2	1		4	1			5	1	1	5	1	83
			2			2						2			1	4						1				1							1		1				3		9				11		40	1		1									1		1	80
			1		1	2					1	1		1	1	20						2				1		1					1		1	1			10	2	6				5		60	2										1	2		1	123

GSC

Figure 8. *Quantitative data from the Port Hood Island section, Cape Breton Island, showing numbers of specimens observed in random traverses.*

England, and Clayton et al. (1977, Pl. 15, fig. 5) recorded it from the Namurian B of Europe. The closely related form, *Ibrahimispores brevispinosus*, is known to occur in the Namurian A, and a specimen called *Ibrahimispores* sp. cf. *I. brevispinosus* occurs in the NC Zone, which straddles the Viséan – Namurian boundary in Europe (Clayton et al., 1977, Pl. 12, fig. 15). If the appearance of *Grandispora spinosa* is somewhat arbitrarily taken as the most significant occurrence, then the assemblage is no older than the VF Zone. In conclusion, from the data available, it would appear reasonable to suggest a late Viséan (V_3) or Brigantian age for the SM Zone. There is no palynological evidence to indicate that the beds are as young as Namurian A (Tables 3 and 7).

b) U.S.S.R.

Meaningful comparisons with the U.S.S.R. have to take into account the immense size of the area, and the fact that in the upper Paleozoic there are a number of well defined vegetational and climatic zones (Meyen, 1982). These vegetational zones are reflected in the palynoflora. Significant differences between the Lower Carboniferous assemblages in various parts of the U.S.S.R. were noted by Luber and Waltz (1941). However, the Viséan assemblages from the Pripyat Depression of Byelorussia (Kedo, 1963, 1966), the Volga-Ural region (Byvsheva, 1967, 1974), and the Donetz Basin (Ischenko, 1956, Teteriuk, 1976, Owens et al., 1978), have many features in common.

TABLE 7

Comparison of miospore assemblages from Western Europe and Atlantic Canada

	WESTERN EUROPE							ATLANTIC CANADA		
AGE	TOURNAISIAN	VISÉAN					NAMURIAN	VISÉAN		
	Tn_3	$V_{1\text{-}2}$	V_3				A	V_2 or V_3	V_3	
SPORE ZONE	CM	PU	TC	NM	VF	NC	TK	NS	AT	SM
Retusotriletes incohatus	×	×						×	×	×
Auroraspora macra	×	×	×	×	×	×	×	×	×	×
Colatisporites decorus	×	×	×	×				×	×	×
Densosporites spp.	×	×	×	×	×	×	×	×	×	
Corbulispora sp.	×	×	×	×						
Verrucosisporites nitidus	×	×						×	×	×
Dibolisporites distinctus	×	×								
Vallatisporites vallatus	×									
Raistrickia clavata	×	×						×	×	
Spelaeotriletes pretiosus (s.l.)	×	×						×	×	×
Crassispora trychera	×	×						×	×	×
Schopfites claviger	×	×						×	×	×
Convolutispora circumvallata	×	×								
Lycospora spp.		×	×	×	×	×	×	×	×	×
Perotrilites tessellatus			×	×	×					
Crassispora aculeata			×	×	×	×				
Schulzospora spp.			×	×	×	×	×			×
Raistrickia nigra				×	×	×				×
Tripartites spp.				×	×	×	×			
Spelaeotriletes arenaceus				×	×	×	×			
Rotaspora spp.				×	×	×	×			
Triquitrites spp.				×	×	×	×			
Grandispora spinosa					×	×	×			×
Savitrisporites nux					×	×	×			
Bellispores sp.						×	×			
Cingulizonates sp. cf. *C. capistratus*						×	×			
Punctatisporites sinuatus						×	×			
Crassispora kosankei						×	×			
Florinites sp.						×	×			
Cirratriradites saturni						×	×			
Stenozonotriletes triangulus							×			

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Note: On the left are genera and species used to differentiate miospore zones in Western Europe (from Neves et al., 1973 and Clayton et al., 1977) and on the right are genera and species that also occur in Eastern Canada.

Difficulties arise when making comparisons between the upper Paleozoic assemblages of the U.S.S.R. and those in other parts of the world. This is because the taxonomic treatment and the presentation of results by Soviet palynologists generally differ from those used by palynologists in many other countries. Owens et al. (1978) discussed these problems when they compared Dinantian to Westphalian assemblages from Northwest Europe with those of the Donetz basin of the U.S.S.R. Nevertheless, they were able to establish approximate palynostratigraphic correlations between the two areas. None of the Viséan assemblages from the above mentioned U.S.S.R. localities is similar to any of those from Atlantic Canada, although the following species are common to the Donetz Basin and Atlantic Canada: *Auroraspora macra*, *Discernisporites macromanifestus*, *Grandispora uncata*, *Lycospora pusilla*, *Retusotriletes incohatus* and *Schopfites claviger*.

In the Lower Carboniferous of Kazakhstan in the lowermost part of the Karaganda Formation, Oshurkova (1976) noted a predominance of *Vallatisporites* and *Crassispora*. These genera are accompanied by *Apiculatisporis*, *Calamospora*, *Camptotriletes*, *Dictyotriletes*, *Schopfipollenites* and *Verrucosisporites*. In the overlying beds, *Florinites* occurs; this genus appears in the Namurian in Western Europe (Clayton et al., 1977). The predominance of *Vallatisporites* and *Crassispora* is somewhat analogous to the Viséan of Atlantic Canada, with its dominance of *Rugospora* and *Crassispora*; a further similarity is the appearance of *Florinites* in the Canso beds overlying the Windsor Group.

In Central Siberia, Dibner (1977) summarized the Carboniferous and Permian palynozones. In the Lower Carboniferous and Namurian the *Lycospora* palynozone was described. This is dominated by species of *Lycospora*, and other important genera are *Capillatisporites*, *Cyclobaculisporites*, *Lophotriletes* and *Raistrickia*. Present also are *Florinites* and *Remysporites*. Dominance of *Lycospora* is not a feature of the Viséan of Atlantic Canada, although species of this genus may be common in the Westphalian (Barss in Hacquebard, 1972).

c) *United States*

Comparisons of the Windsor assemblages with localities in the United States were summarized by Utting (1980). It seems probable that most of the assemblages from the U.S.A. summarized in Table 8, with the exception of certain material from Tennessee, are younger than the AT Zone of the Upper Windsor.

Illinois and Kentucky

Assemblages from the Hardinsburg Formation of Illinois and Kentucky described by Hoffmeister, Staplin and Malloy (1955) contain *Grandispora spinosa* and *Schulzospora* spp. suggesting a correlation with beds no older than the SM Zone. Felix and Burbridge (1967, Table 1), suggested a late Viséan age for the formation. Sullivan and Mishell (1971) thought that the Hardinsburg Formation might be slightly older than the Goddard Formation and placed the Viséan/Namurian boundary at the base of the Goddard Formation. Wiggins (1962) found rare specimens of *Florinites* in the Goddard Formation, and Sullivan and Mishell (1971) reported *Potonieisporites elegans*; both these occurrences suggest a Namurian age. This conclusion is supported by evidence from goniatites, which occur in the lower part of the Goddard Formation, and which were correlated by Elias (1956) with the E_1 of the Namurian.

Using conodonts, Lane and Straka (1974) correlated the Goddard Formation with the pre-upper H_1B of the Namurian of Belgium and Germany. The upper part of the formation was assigned to the *Adetognathus unicornis* Zone, the middle part to the *Kladognathus-Cavusgnathus naviculus* Zone, and the lower part to the pre-*Kladognathus-Cavusgnathus naviculus* Zone. Higgins (1975) correlated the *Kladognathus-Cavusgnathus naviculus* Zone in the Upper Mississippi Valley with the Namurian $E_1$of NW Europe.

Ettensohn and Peppers (1979) suggested that in the northeastern part of Kentucky, the uppermost part of the Glen Dean Member of the Newman Limestone and the Lower Dark Shale Member of the Pennington Formation were Viséan V_3. The assemblages from this unit resemble those from the SM Zone of Atlantic Canada in certain respects (see Table 8). However, there are many species in the Kentucky material that are lacking in the present study area. Samples from the upper clastic member of Namurian A age contain *Crassispora kosankei* (Potonié and Kremp) Smith and Butterworth, *Florinites* spp. and *Reinschospora speciosa* (Loose) Schopf, Wilson and Bentall. Ettensohn and Peppers (1979) proposed a Viséan V_3 age for the upper part of the Newman Limestone and the lower part of the Pennington Formation of northeastern Kentucky, whereas, for similar beds in northern Tennessee, Horowitz et al. (1979) considered all of the Pennington Formation and the underlying Bangor Limestone to be of Namurian age. This would suggest either that these units are time transgressive, or that the age determinations made for one, or both, of the localities are not correct.

Tennessee

Palynological data were obtained by Neves (in Horowitz, Mamet, Neves, Potter and Rexroad, 1979) from Tournaisian, Viséan, and Namurian rocks in a borehole in Scott County, Tennessee. *Lycospora pusilla* was recorded in rocks dated as late Tournaisian (Tn3c) from the foraminiferal data of Mamet. Similarly, *Lycospora* is known to appear in the latest Tournaisian rocks of Western Europe (Clayton et al., 1977). This unit in Tennessee was the Fort Payne Formation, which these workers correlated with the Keokuk Limestone of the Upper Mississippi Valley.

From rocks of Viséan V_2 age (Warsaw Formation and lower St. Louis Limestone), Neves recorded *Calamospora* spp., *Densosporites anulatus* (Loose) Smith and Butterworth, *Densosporites intermedius* Butterworth and Williams, *Densosporites spinosus* Dybová and Jachowicz, *Discernisporites macromanifestus* (Hacquebard) comb. nov., *Lophozonotriletes muricatus* Hibbert and Lacey, *Lycospora pusilla* (Ibrahim) Schopf, Wilson and Bentall, *Microreticulatisporites punctatus* Knox, *Murospora intorta* (Waltz) Playford, *Punctatisporites solidus* Hacquebard, *Rugospora corporata* Neves and Owens, *Spelaeotriletes echinatus* (Hacquebard) comb. nov., *Spelaeotriletes triangulus* Neves, *Triquitrites comptus* Williams and *Verrucosisporites nodosus* Sullivan and Marshall. He suggested that this assemblage may be partly equivalent to the *Perotrilites tessellatus* - *Schulzospora campyloptera* (TC) Zone of Neves et al. (1972).

This assemblage differs from those found in both the Windsor Group and Windsor/Canso Group boundary beds, but *Lycospora pusilla*, *Rugospora corporata*, and *Spelaeotriletes echinatus* are species common to both localities. The reason that the assemblages have so little in common is difficult to explain. If the conclusions in this paper and that by Utting (1980) are correct, then the AT Zone of Atlantic Canada corresponds partly to the TC Zone of Europe. However, Atlantic Canada and northern Tennessee may not have been

LOCALITIES	LITHOSTRATIGRAPHIC UNIT	MACROFAUNAL SUBZONE	CONCURRENT RANGE ZONE	SAMPLE NUMBER OR LOCALITY	*Acanthotriletes hacquebardii*	*Anapiculatisporites fundiensis*	*Auroraspora macra*	*Auroraspora solisortus*	*Biannulatisporites simplex*	*Calamospora parva*	*Chomotriletes multivittatus*	*Colatisporites decorus*	*Convolutispora labyrinthea*	*Convolutispora mellita*	*Convolutispora tessellata*	*Convolutispora vermiformis*	*Crassispora trychera*	*Cristatisporites submarginatus*	*Densosporites columbaris*
STEWIACKE BOREHOLE SB-1 C-090406				C-090406															
	WINDSOR/CANSO BOUNDARY		SM	99			1		1	1		1	1		1		36		
				97			1						1	1	1	1	13		
	UPPER WINDSOR	E	AT	83		2							3		1	1	50		
		D		75			1				1	1	4	1	1	1	7		
		C		71									1	1	1	1	32		
	LOWER WINDSOR	B	NS	45	1		1	1					1		1		43		
		A		38			1	1	1	1		1	1		1	1	64		2
				33		1				1			1		1		22		
				21		1	1			1		1	4			1	10		
SELECTED OUTCROP SAMPLES FROM NOVA SCOTIA AND NEWFOUNDLAND	WINDSOR/CANSO BOUNDARY		SM	C-097712								1	2	9	1	1	85	1	
	U. WINDSOR	D	AT	C-090402						1		2	6	1	1	1	61	5	
	LOWER WINDSOR	B	NS	D-1014 (JS1-72-0-30) and C-090404			1			1		2	1		1		60		1
		A		Rom-Bos-1-2		2	1					1	1	1	1		70	1	
				Rom-Shp-Cv-4-3	1		1	1				1	1		1		70		1

SAMPLE NUMBER OR LOCALITY	*Dictyotriletes odontolophos*	*Discernisporites diaphanes*	*Discernisporites macromanifestus*	*Discernisporites micromanifestus*	*Grandispora spinosa*	*Grandispora uncata*	*Granulatisporites tuberculatus*	*Ibrahimispores magnificus*	*Knoxisporites literatus*	*Knoxisporites probolos*	*Knoxisporites stephanephorus*	*Knoxisporites triradiatus*	*Leiotriletes inermis*	*Leiotriletes ornatus*	*Lycospora noctuina* var. *noctuina*
C-090406															
99				1	1		1	1		1	1	5			4
97				1	1		1				2	1		1	
83										1			1		1
75	1		1						1	1	1				
71									1		1				
45									1		1				1
38				2					1		1		1		1
33				1					1		1		1		
21		1				1				1	1				
C-097712	1			1				1		1	1			1	
C-090402	1			1		1	1			1	1		1	1	1
D-1014 (JS1-72-0-30) and C-090404				1										1	1
Rom-Bos-1-2				1					1						
Rom-Shp-Cv-4-3				1			1							1	2

SAMPLE NUMBER OR LOCALITY	*Lycospora pusilla* "tendance B2"	*Microreticulatisporites hacquebardii*	*Punctatisporites irrasus*	*Punctatisporites minutus*	*Punctatisporites planus*	*Pustulatisporites multicapitis*	*Raistrickia baculosa*	*Raistrickia clavata*	*Raistrickia magdalena*	*Raistrickia nigra*	*Retusotriletes incohatus*	*Rugospora corporata* var. *verrucosa*	*Rugospora minuta*	*Rugospora polyptycha*	*Schulzospora bilunata*
C-090406															
99			1	1	4	1			1		4	1	9	1	2
97			1	1	2	1	1		1	1	1	1	6		
83			1	1	7			1	1		1		23	1	
75			1	1	1				1		1		1	1	
71				1		1					1		8	1	
45			2		1	1					1		60		
38			5	1	29						5		17	2	
33			1	1	6			1			4		3		
21					4						2		33	1	
C-097712					1		1		2	1	2	1	3		
C-090402			3		2	1		1	1		2		32	3	
D-1014 (JS1-72-0-30) and C-090404			8		9						6		20		
Rom-Bos-1-2		5	4	1	9			1			5		15		
Rom-Shp-Cv-4-3	4	2	1	4				1					8		

SAMPLE NUMBER OR LOCALITY	*Schopfipollenites acadiensis*	*Schopfites claviger*	*Scutulum trisupplementum*	*Secarisporites lobatus*	*Spelaeotriletes echinatus*	*Spelaeotriletes pretiosus* var. *bellii*	*Spelaeotriletes pretiosus* var. *windsorensis*	*Spelaeotriletes tuberosus*	*Tricidarisporites arcuatus*	*Vallatisporites ciliaris*	*Vallatisporites verrucosus*	*Verrucosisporites morulatus*	*Verrucosisporites nitidus*	*Verrucosisporites papulosus*	Total number of specimens
C-090406															
99	29	1		1		1	1		1			1		3	120
97	2	1	1							1			1		47
83						1	1	1		1					100
75	1							1				1			32
71		3				1						1			55
45		5								1		1			123
38		1				1				1		1	1	1	145
33		2				1									49
21		1									1		1		66
C-097712	1	4										2		1	125
C-090402	1	2	2				3	1				2	1	2	146
D-1014 (JS1-72-0-30) and C-090404						1				1		2	1	1	119
Rom-Bos-1-2		7			1	1				8		2	3	7	149
Rom-Shp-Cv-4-3		3			1					18		1	2	1	128

GSC

Figure 10. Quantitative data from selected samples in Stewiacke borehole SB-1, Shubenacadie, Nova Scotia, and from outcrops with good stratigraphic control in Nova Scotia and Newfoundland (C-097712; C-090402; D-1014-JSI-72-0-30; and C-090404 from Cape Dauphin, Cape Breton Island, Nova Scotia. Boswarlos ROM-BOS-1-2 and Fischells Brook ROM-Shp-Cv-4-3 from southwestern Newfoundland).

TABLE 8

Comparison of selected species present in certain localities of the United States and Atlantic Canada

	ILLINOIS AND KENTUCKY	SOUTHERN OKLAHOMA			KENTUCKY		
					PENNINGTON FM.[5]		
	HARDINSBURG FM.[1]	GODDARD FM.[2, 3, 4]	SPRINGER FM.[2]	MORROW FM.[2]	a) Dark shale member	b) Upper clastic member	LEE and BREATHITT FMS.[5]
Auroraspora solisortus	×	×	×				
Convolutispora tessellata	×			×			
Convolutispora vermiformis		×	×	×	×		
Crassispora kosankei			×		×		×
Crassispora trychera							
Discernisporites micromanifestus			×	×			
Florinites spp.		×	×	×		×	×
Grandispora spinosa	×	×	×	×	×		
Granulatisporites tuberculatus	×			×	×		
Knoxisporites stephanephorus		×	×	×		×	
Knoxisporites triradiatus	×	×	×	×	×	×	×
Lycospora noctuina		×	×		×		
Lycospora pusilla							
Potonieisporites elegans		×	×	×			
Reinschospora spp.		×	×		×		×
Retusotriletes incohatus				×			
Rotaspora spp.	×	×	×				
Rugospora minuta							
Savitrisporites nux		×	×	×		×	×
Schopfipollenites acadiensis							
Schopfipollenites ellipsoides							
Schopfites claviger				×			
Schulzospora spp.	×	×	×	×	×		×
Vestispora spp.				×	×		

[1] Hardinsburg Formation; Hoffmeister, Staplin and Malloy (1955)

[2] Goddard, Springer and Morrow formations; Felix and Burbridge (1967)

[3] Goddard Formation; Wiggins (1962)

[4] Goddard Formation; Sullivan and Mishell (1971)

[5] Pennington Formation, a) Lower dark shale member locally intercalated with the uppermost part of the Glen Dean member of the Newman Limestone Formation, b) Clastic member. Lee and Breathitt formations; Ettensohn and Peppers (1979)

TABLE 8 (cont.)

TENNESSEE			ATLANTIC CANADA			
WARSAW and ST. LOUIS FMS.[6]	GLEN DEAN and PENNINGTON FMS.[6]	GIZZARD GP.[6]	LOWER WINDSOR GP.[7]	UPPER WINDSOR GP.[7]	WINDSOR-CANSO GP. BOUNDARY[7]	CANSO GP. U. HASTINGS FM. POMQUET FM.[8]
	×	×	×	×		×
			×	×	×	
			×	×	×	
		×				
×	×		×	×	×	
	×		×	×	×	×
		×				
	×				×	×
			×	×	×	
	×		×	×	×	×
	×	×		×	×	×
			×	×	×	
×	×	×	×	×		
		×				×
		×				
	×		×	×	×	
×	×	×	×	×	×	
	×	×				
				×	×	×
	×	×				
	×		×	×	×	
	×				×	×
	×					

GSC

[6] Warsaw and St. Louis formations, Glen Dean and Pennington formations; Horowitz, Mamet, Neves, Potter and Rexroad (1979)

[7] Lower and Upper Windsor Group and Windsor-Canso Group boundary; this paper

[8] Upper Hastings Formation and Pomquet Formation; Neves and Belt (1971)

in the same paleolatitude; but the fact that they had approximately the same latitude, is suggested in the reconstruction of the mid-Carboniferous by Smith, Hurley and Briden (1981). Paleoenvironmental differences may be partly responsible for the dissimilarity of the assemblages, and this aspect is discussed further in the "Paleoecological implications" section.

In the upper part of the St. Louis Limestone of V_3 age occur *Crassispora trychera* Neves and Ioannides, *Perotrilites perinatus* Hughes and Playford, *Rugospora minuta* Neves and Ioannides. Both *Crassipora trychera* and *Rugospora minuta* are important components of the Windsor assemblages.

In the Bangor Limestone and Pennington formations, Neves found assemblages that he correlated with the *Bellispores nitidus* - *Reticulatisporites carnosus* (NC) Zone of Neves et al. (1972). He pointed out that this zone spans the Viséan/Namurian boundary in England (Horowitz et al., 1979, p. 21), but in Figure 2 of the same publication, all of the beds containing this assemblage zone are shown as Namurian A. Also, in the same Figure 2, the lower part of the Bangor Limestone is shown to contain the conodont zone *Gnathodus bilineatus* - *Kladognathus mehli* of Collinson et al. (1971), yet this zone was shown by these workers (Collinson et al., 1971, Table 1) to be late Viséan. In the Bangor Formation, Mamet (in Horowitz et al., 1979) recorded foraminifers, which he placed in Zone 17; he assigned Zone 17 to Namurian A. In 1970 he had determined a similar age for the middle and upper part of macrofaunal Subzone E of the Windsor Group in Atlantic Canada.

In the beds assigned to the NC Zone, Neves (in Horowitz et al., 1979) recorded all the species listed for the older TC Zone, but in addition the assemblage included (amongst others) *Auroraspora balteola* Sullivan, *Crassispora maculosa* (Knox) Sullivan, *Grandispora spinosa* Hoffmeister, Staplin and Malloy, *Knoxisporites stephanephorus* Love, *Knoxisporites triradiatus* Hoffmeister, Staplin and Malloy, *Savitrisporites nux* (Butterworth and Williams) Sullivan, *Schopfipollenites ellipsoides* (Ibrahim) Potonié and Kremp, *Schulzospora* spp., *Tricidarisporites serratus* (Playford) Sullivan and Marshall, *Tripartites distinctus* Williams, *Tripartites vetustus* Schemel, *Triquitrites comptus* Williams, *Triquitrites marginatus* Hoffmeister, Staplin and Malloy, and *Waltzispora planiangulata* Sullivan. This assemblage differs from the SM Zone of Atlantic Canada by the presence of species such as *Crassispora maculosa*, *Savitrisporites nux*, *Tricidarisporites serratus*, *Tripartites* spp., *Triquitrites* spp. and *Waltzispora planiangulata*, but it is similar in possessing such forms as *Grandispora spinosa* and *Schulzospora* spp. It may be only slightly younger than the SM Zone, which has been correlated in this paper with the *Tripartites vetustus* - *Rotaspora fracta* (VF) Zone, which underlies the NC Zone in Europe. On the other hand, like the Viséan V_2 beds of Atlantic Canada and northern Tennessee, paleoenvironmental variations may partly be the reason for the differences in the assemblages, rather than any significant age difference.

Unfortunately, no assemblages were found in the Tennessee beds between the TC and NC zones (e.g., *Raistrickia nigra* - *Triquitrites marginatus* Zone and *Tripartites vetustus* - *Rotaspora fracta* Zone), but when such information becomes available it may prove to be of considerable value in correlating the late Viséan of North America.

In the Gizzard Group overlying the Pennington Formation, Neves (in Horowitz et al., 1977) recorded a Namurian B assemblage, which included such forms as *Florinites* spp. and *Reinschospora speciosa* (Loose) Smith and Butterworth.

d) Other parts of the world

Detailed comparison with other parts of continents that may have been at a similar latitude to Eastern Canada in the mid-Carboniferous is not yet possible, due to lack of data. If, for example, the reconstruction proposed by Smith, Hurley and Briden (1981) for the mid-Carboniferous is correct, then one may anticipate certain similarities with assemblages in the northwestern part of South America and the northwestern part of Africa. Data from the northwestern part of South America are not yet available and it is not possible to make comparisons. Information from the Algerian Sahara given by Lanzoni and Magloire (1969) suggests that the assemblages from the Viséan of this part of Africa have more in common with those from Western Canada, the Arctic Islands and Spitzbergen than those from Atlantic Canada. For example, cingulate genera such as *Densosporites* and *Murospora* are common in the Viséan V_2; in the upper Viséan V_3, *Densosporites* and related genera and *Verrucosisporites* are common.

Other assemblages described from Algeria are significantly different from the palynoflora of Atlantic Canada. In the Illizi basin of the Algerian Sahara, Attar et al. (1980) recorded assemblages from the Upper Devonian (Famennian) to the Upper Carboniferous (Namurian). In their Zone IV of Viséan age, they found abundant specimens of *Grandispora balteata* Playford. *Densosporites variomarginatus* was also common. In the upper part of the zone the following species appear: *Radiizonates genuinus* (Juschko) Loboziak and Alpern, *Spelaeotriletes owensi* Loboziak and Alpern, *S. triangulus* Neves and Owens, *Vallatisporites agadesi* Loboziak and Alpern, *V. ciliaris* Sullivan and *Waltzispora* Staplin. *Verruciretusispora* spp. are present in significant numbers in the lower part of the zone but decrease in significance with the increase in abundance of *Spelaeotriletes owensi* in the upper part of the zone. Acritarch genera *Veryhachium* Deunff and *Micrhystridium* (Deflandre) Downie and Sarjeant occur along with *Tasmanites* Newton.

In Zone V, of late Viséan to Namurian age, *Lycospora* is first recorded, although it is relatively rare. *Waltzispora* becomes more important. Present also are rare specimens of *Crassispora maculosa* (Knox) Sullivan and *Tripartites*. *Grandispora balteata* disappears at the top of the zone. At the base of Zone VI, of Namurian to Westphalian age, *Schopfipollenites* appears. Slightly above the base *Potonieisporites elegans* occurs and *Lycospora* becomes increasingly common. Many of the species recorded in Zone V continue into Zone VI.

It would appear that the differences outlined above may also apply to rocks of similar age in Libya (Massa et al., 1980), Egypt (Schrank, 1984) and Nigeria (Loboziak and Alpern, 1978). For example, in the Agadès Coal Basin in Nigeria, miospores from rocks of late Viséan age were described by Loboziak and Alpern (1978). They noted the presence of *Lycospora pusilla* and abundant specimens of *Vallatisporites*. Also numerically important were cingulate genera including *Densosporites*, *Cingulizonates* and *Radiizonates*, and the genera *Kraeuselisporites*, *Apiculiretusispora*, *Anapiculatisporites* and *Anaplanisporites*.

Assemblages tentatively assigned to the earliest Viséan were described by Clayton and Loboziak (1985) from Libya. These contain abundant specimens of *Spelaeotriletes balteatus* (Playford) Higgs, along with *Spelaeotriletes owensi* Loboziak and Alpern, *Radiizonates genuinus* (Jushko) Loboziak and Alpern and *Vallatisporites agadesi* Loboziak and Alpern. In the lower part of the interval the assemblage is supplemented by *Spelaeotriletes pretiosus* and *Vallatisporites* *vallatus* Hacquebard. These assemblages, which are older than the Windsor Group, are very different from the material described here and more closely resemble that recorded from the Horton Group by Hacquebard (1957) and Playford (1964). An association which was tentatively dated as late Viséan and early Serpukhovian contained *Lycospora* and *Spelaeotriletes triangulus* Neves and Owens. Their appearance coincides with the tops of the ranges of *Radiizonates genuinus*, *Spelaeotriletes balteatus*, *Spelaeotriletes owensi* and *Vallatisporites agadesi*. Present also are *Foveosporites appositus* Playford, *Tricidarisporites serratus* (Playford) Sullivan and Marshall, and *Waltzispora planiangulata* Sullivan. Even though this association is of approximately similar age to the upper Windsor Group and the Windsor-Canso boundary beds, there is little in common between the two localities.

Conclusions

A Viséan V_2-V_3, or Arundian(?) to Holkerian, age is suggested for the spore assemblages in the NS (Lower Windsor) Zone, and a V_3, or Asbian, age for the AT (Upper Windsor) Zone of Atlantic Canada (see Table 3). This is similar to the ages proposed by Bell (1929) for the Lower (A and B) and Upper (C, D and E) Windsor macrofaunal zones of the Windsor Group, and compares with a Viséan V_2, or Holkerian, age proposed by von Bitter and Austin (1984) for the upper part of Subzone B. Differences between the assemblages of the NS and AT zones are slight, suggesting that although a hiatus may be present, it is not great. Similarly, the presence of most other fossil groups indicates that there is a perceptible, but not great, biostratigraphic change at the boundary of macrofaunal Subzones B and C. No palynological evidence was found to suggest that the SM Zone was younger than Viséan V_3, or Brigantian, in age. Such an age would not be inconsistent with that proposed by Neves and Belt (1970) but is not supported by the evidence Mamet (1970, p. 17) provided from his studies of foraminifers and algal microflora. He stated:

> "The lower part of subzone E belongs also to the latest Viséan zone 16 sup. but the characteristic assemblage *Asteroarchaediscus baschkiricus* (Krestovnikov and Teodorovitch) – *Endothyranopsis sphaerica* (Rauzer-Chernoussova and Reitlinger) is present in the upper part of the subzone; therefore subzone E straddles the Viséan-Namurian boundary, but is not equivalent to much of the early Namurian, in that no *Globivalvulina*? has been observed."

Globensky (1967), who compared the conodonts of the Windsor Group with those of Western Europe, suggested that the Windsor Group falls within the age range of middle Viséan to early Namurian.

It is possible that the present discrepancies concerning the placing of the Viséan/Namurian boundary will be resolved after further work in North America, Western Europe and elsewhere in the world.

Paleoecological implications

Palynological preparations from the Windsor Group and Windsor-Canso Group boundary beds and their lateral equivalents contain spores and rare scolecodonts. Very rare, spinose acritarchs were found in the Windsor Group.

The miospore assemblages are unusual in that they are generally dominated in the Windsor Group by *Crassispora trychera* and *Rugospora minuta*, and in the overlying Windsor-Canso Group boundary beds by *Crassispora trychera* only. In the Windsor Group, the dominance by one or both of the two species mentioned above occurs throughout the study area, in all strata containing palynomorphs (grey shale, siltstone, and argillaceous carbonate, salt and anhydrite), and at all stratigraphic horizons. Such uniformity, vertically and laterally, and in a variety of lithotypes, is unlikely to be the product of selective sorting during water transport. More probably, it indicates that the vegetation on the land surrounding the Fundy Basin was lacking in variety, and that spores were dispersed over the basin by the wind before settling to the bottom of the almost stagnant water, with little further transportation or sorting.

The high proportion of evaporites present in the Windsor Group suggests an arid climate. A similar conclusion was reached by Van der Zwan et al. (1985). They were able to show that a dry climate existed during the Viséan in Atlantic Canada by applying a multivariate statistical analysis to the available palynological data from the Lower Carboniferous. The latitude of the study area in the Viséan, according to most reconstructions of the continents, would have been close to the Equator (Smith, Hurley and Briden, 1981) and thus a hot, arid climate would have been likely. Such a climate may well have resulted in the land area being dominated by very few species of plants. A somewhat similar phenomenon was suggested by Vakhrameev (1981) in the Jurassic and Cretaceous of the U.S.S.R., where dominance of *Classopollis* (60-75% and occasionally 90%) in the palynological assemblages was thought to have been the result of a hot, arid climate. However, as pointed out by Srivastava (1976), the mere presence of the genus may indicate that the plants producing it had a wide range of tolerance from a dry to a wet climate in coastal to upland areas.

The tectonic setting would have greatly influenced the paleogeography during Windsor times. The thin basal carbonates and the massive evaporites (Subzone A) of the Lower Windsor have been interpreted as both shallow water (Schenk, 1969) and deep water deposits (Evans, 1970; Geldsetzer, 1977, 1978), whereas there is general agreement that the overlying carbonate-evaporite succession (Subzone B) of the Lower Windsor, as well as the interbedded carbonates and red clastics (Subzones C to E) of the Upper Windsor are of shallow water origin. Schenk (1969) suggested that deposition took place in a complex rift system where hypersaline seas repeatedly flooded the intrabasinal grabens, which probably were interconnected. He believed the massive evaporites were deposited in a supratidal environment, but Evans (1970) suggested that they were the result of rapid sedimentation, possibly in deep water. Mamet (1970) proposed four main depositional environments in the Windsor Basin: an open marine, carbonate platform facies; oolitic and algal bank facies; lagoonal supersaturated and a restricted shallow marine, hypersaline facies grading into intertidal-supratidal flats; and a continental facies. The fact that some of the beds were deposited in very shallow water and that the sediments may have been exposed for short time intervals is suggested by the presence of tetrapod tracks in lateral equivalents of the Upper Windsor Group (see Utting, 1966; Appendix 3, SW Newfoundland, section E, a). Von Bitter (1976) pointed out that the conodont faunas for the Windsor Group, above the massive evaporites of Subzone A on Port Hood Island, Cape Breton, were characteristic of shallow water shelf deposits, although the occurrence of one genus, *Gnathodus*, may indicate that certain beds were deposited in deeper water nearer the basin. Kirkham (1978) discussed the restricted nature of the basins where salinities were so high that large quantities of sulphate and salt were precipitated. He also pointed out that there must have been some occasions, such as immediately after the initial transgression, or as a result of brief influxes of less saline water, when salinity was low enough for corals, crinoids, brachiopods, gastropods and bryozoans to live. However, a shallow marine, hypersaline facies may have persisted while the Windsor Group was being deposited, even when conditions of normal to slightly supersaturated salinity occurred farther out to sea (Mamet, 1970). Geldsetzer (1978) favoured deposition in a wide, land-locked, trough-like embayment, which was probably connected to an oceanic seaway east of the continental shelf of Nova Scotia. He also suggested that the presence of both the basal cryptalgal laminite and equivalent bioherms of Subzone A indicated the establishment of hypersaline conditions relatively soon after the initial Windsor marine transgression. Geldsetzer (1977) drew attention to the similar tectono-sedimentary settings of the Windsor Group and the Upper Permian Zechstein Group of western Europe and speculated that, if rates of evaporite deposition were compatible, the massive evaporites of Subzone A could have accumulated in as little as 150 000 years.

Most workers have proposed a limited connection with the ocean, which may have partially contributed to the general lack of acritarchs in the Windsor Group. High salinity may also have inhibited the growth of plants along the shoreline; such a phenomenon was recorded elsewhere by Krasilov (1975, p. 76). The lack of shoreline vegetation may explain the lack of any significant variation in the quantitative data close to the shoreline of the Fundy Basin. A possible example of such an area is the Hopewell Cape region of New Brunswick, where coarse clastics appear in the Windsor beds. However, at this locality, the assemblages are quantitatively similar to other parts of the study area where no coarse clastics are present. One locality where finer clastic sediments are common is in the Frenchvale Brook - Balls Creek area, and this area was relatively close to the shoreline, according to Geldsetzer (1977, Fig. 86.1). The spore assemblage from GSC plant locality 1659 was qualitatively similar to those from other lower Windsor samples, but differs in that it contains a significant number (15) of specimens of *Densosporites columbaris*, a species that is normally very rare or absent. The presence of species of *Densosporites* has been taken by some workers (e.g. Habib, Riegel and Spackman, 1966) to suggest the presence in the Upper Carboniferous of an environment not unlike that found in the recent euryhaline red mangrove swamps of Florida. Thus, marine shoreline sediments of Carboniferous age may include significant numbers of *Densosporites* spp. Species of this genus are probably derived from herbaceous lycopods (Ravn and Fitzgerald, 1982). In some parts of the Appalachians, such as northern Tennessee, a number of species of *Densosporites* occur in Viséan beds (Horowitz et al., 1979). Absent from this succession are significant evaporite deposits, but as pointed out by Geldsetzer (1978), Viséan rocks were deposited west of the Appalachians on a wide craton and in a more open environment than Atlantic Canada. For example, in eastern Tennessee, the Mississippian deposits are thick and dominated by terrigenous deposits laid down in the rapidly subsiding Appalachian foredeep; in the west they are thin and were deposited on a stable carbonate platform (Milici et al., 1979, p. G1). Another explanation for the relative lack of species of *Densosporites* in the Windsor Group could be the arid climate. For example, Van der Zwan et al. (1985) suggested that an abundance of *Densosporites* was a feature of a flora in a humid environment.

The plant affinities of many of the spores in the Windsor beds are not precisely known. It is probable that *Lycospora* spp. is produced by an arboreal lycopod growing in fresh water localities (Habib, Riegel and Spackman, 1966). Unfortunately, the affinities of the abundant spore *Crassispora trychera* are not yet known. The affinities of the similarly abundant perisporate genus *Rugospora* are uncertain, but, as was suggested for saccate pollen by Chaloner (1958), it may have been easily transported by the wind into an environment other than that in which it originated. Also unknown is the reason for the smaller size range for certain species recorded in the Windsor Group compared with the size of those described from the Horton Group, e.g., *Raistrickia baculosa*, *Raistrickia clavata* and *Verrucosisporites papulosus*. It is possible that the smaller size of the Windsor species may be the product of selective sorting and concentration during transportation by the wind, or different processing techniques, or the unusual depositional geochemistry of the group.

The Windsor-Canso Group boundary reflects the change to essentially lacustrine conditions (Neves and Belt, 1970). That the salinity remained high is suggested by the presence of anhydrite intercalations in the lower beds. Also, the climate presumably remained arid, if dominance by a single species (*Crassispora trychera*) can be taken as a valid indicator.

Thus, in conclusion, the following observations for the Windsor Group can be made:

1. The climate was hot (proximity to equator) and arid (abundant evaporites).

2. The tectonic setting was a marine basin in a land-locked, trough-like embayment. There was limited connection to the ocean, which may explain the scarcity of acritarchs.

3. During deposition of Subzone A, hypersaline conditions were especially severe and this continued during deposition of Subzone B. When the rocks of Subzones C, D and E were deposited, occasional, at times localized, normal marine conditions permitted the temporary existence of marine animals, including brachiopods, corals, molluscs and trilobites.

4. The vegetation on land lacked variety and was dominated by a few species.

5. The shoreline probably lacked vegetation much of the time due to the high salinity of the seawater and, possibly, the groundwater. Only a few species of plants, which might have been able to tolerate such saline conditions, could have survived. Herbaceous lycopods were probably rare, although a few species may have flourished in areas where meteoric groundwater was periodically available.

6. Spore transportation was probably mainly by wind, which would account for the consistent quantitative proportions vertically and laterally.

7. There was little retransportation of the spores once they had entered the mainly stagnant water.

Most of these observations would also apply to the Windsor-Canso Group boundary beds, but higher up in the Canso Group, marine conditions had ceased, and terrestrial, more temperate conditions were established, providing new environments for plant growth.

Thermal alteration

The thermal alteration was estimated according to the colour of the spores. There are a number of scales used for assessing the Thermal Alteration Index, e.g. in Correia (1969), Staplin (1969) and Reaugh and Bayliss (1978). They are all based on the same phenomenon, which is that palynomorphs and certain components of the organic matter (such as exinous material) change colour as maturation increases. These colour changes have been given numerical indices, although the numbers assigned may differ from one scale to another. In this paper a modified version of the five point scale proposed by Correia (1969) has been used. The modifications that allow for intermediate divisions between Correia's scale are shown in Table 9 and are based on spore and pollen colours. The species used to determine the indices were *Crassispora trychera* and/or *Rugospora minuta*. In most cases the rock types were grey siltstone or shale intercalations; occasionally evaporites were used if siltstone and shale were absent.

The Thermal Alteration Indices obtained are shown in Figures 2, 3, 4, 6. The results indicate that although there are significant variations within Atlantic Canada, they fall within the range of T.A.I. 2- to 4 (see Figure 11). Moreover, the majority of samples have a T.A.I. within the relatively limited range of 2- to 3; this level of maturation, according to Reaugh and Bayliss (1978), would be suitable for the generation of oil.

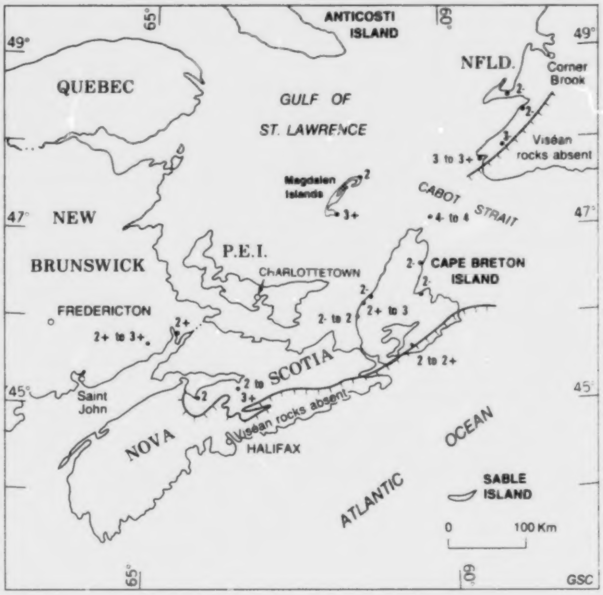

Figure 11. *Thermal Alteration Indices of study area.*

In Nova Scotia, low values are common, in Cape Breton Island they range from T.A.I. 2- to 2+ for the Windsor Group and the Windsor-Canso Group boundary beds, although slightly higher values (2+ to 3) were found in the Windsor-Canso Group boundary beds at Broad Cove. The reason for this anomaly is not clear, but it may be the result of some local, fault-related, tectonic activity. On mainland Nova Scotia in Stewiacke borehole SB-1, the maturation is low in the upper part of the well (T.A.I. 2), but increases with depth to T.A.I. 3+ at the bottom. In the samples from the evaporite units, the thermal alteration indices may vary within a single sample and light brown spores may occur with dark brown, to almost black, spores of the same species. The black spores may have been altered at a time when movement was taking place within the salt along relatively narrow planes, and where considerable heat may have been generated. On the other hand, it may be the result of some localized chemical activity, which selectively altered certain spores; this may be related to geochemical exchanges between exinite and the 'salt' matrix (Neves, pers. comm., 1984).

TABLE 9

Criteria used to assess Thermal Alteration Indices

Colour of spores and pollen in transmitted light	Thermal Alteration Index
Transparent to pale yellow	1
Yellow	1+
Yellow to light orange	2-
Medium orange	2
Dark orange to light brown	2+
Medium brown	3-
Dark brown	3
Thinner parts of spore exine dark brown, thicker parts brownish black	3+
Thinner parts of exine brownish black, thicker parts black	4-
Black, haptotypic mark barely visible	4
Metallic black, fossils brittle, often fractured, rarely identifiable. (Haptotypic mark may be visible with reflected light)	5

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In New Brunswick in the Lower Windsor at Hopewell Cape, the thermal indices are low (T.A.I. 2+). In Kings County in Millstream No. 1 borehole, the indices in evaporites of the Lower Windsor Group vary from T.A.I. 2+ to 3+ within a single sample; this is a similar phenomenon to that described above for the evaporites in Stewiacke borehole SB-1.

In the Magdalen Islands, maturation indices in the Cape Adèle Member (Lower Windsor) are relatively high. For example, five samples (C-090436 to C-090440), collected from the south side of Île du Havre-aux-Maisons (see Figure 3B) from steeply dipping, thin, grey bands within the red-brown siltstone and gypsum beds, had thermal indices of T.A.I. 3+. At this locality, the Lower Windsor rocks are intercalated with volcanic tuffs, but there does not appear to be any increase in the level of maturation, even in the samples collected immediately at the contact with the tuffs (e.g., C-090440). Similar results were also obtained from three samples (C-097719 to C-097721) collected approximately 3 km east-northeast, at a point 0.6 km to 1 km north of Anse Firmin (see Figure 3A). On Île Boudreau, five samples (C-090441 to C-090445, see Figure 3) were collected from Upper Windsor equivalents (Bassin-aux-Huîtres Member). Here there is no evidence of any volcanic activity and the thermal index was low (T.A.I. 2). This suggests that higher thermal alteration is related to areas of volcanic activity.

In southwestern Newfoundland, the Thermal Alteration Index between Codroy and Searston villages at the southwestern end of the Codroy Valley is relatively high (T.A.I. 3 to 3+); this applies to Lower Windsor equivalents

(Woodville Formation), Upper Windsor equivalents (Woody Cape Formation) and Windsor-Canso Group boundary equivalents (Searston Formation). The fact that this high level of maturation applies to the complete section suggests that it may be of a regional nature and may be the result of tectonic activity. However, it would seem to be restricted to the southwestern part of the valley, because 20 km east, samples from the North Branch Formation (C-090420 to C-090425) in the channel of the Grand Codroy River are less mature (T.A.I. 3-), and in the area adjacent to St. George's Bay (Heatherton, Fischeli and Romaines Brook) and on the north side of Port au Port Peninsula (Boswarlos and Aguathuna), the Lower Windsor sediments are immature (T.A.I. 2-). On the other hand, in the Cabot Strait (Petro-Canada et al., St. Paul P-91), the T.A.I. for the Windsor sediments is as high as 4.

SYSTEMATIC PALYNOLOGY

The samples forming the basis of the work for this paper were obtained from a variety of sources; further details concerning the collection localities and stratigraphic positions are given in Appendix 3. Some of the samples come from rock units that bear informal names; these names are shown in quotation marks. Many of the samples were collected by workers other than the author, and their names are listed in Appendices 1 and 2, along with the curation and field numbers, and a key to locality numbers. In the systematics section, localities, sample numbers, slide numbers, grid references of specimens, and type numbers are indicated by a series of digits. An example, with the explanations in parentheses, is given below: D (Atlantic Geoscience Centre, Dartmouth) - 1384 (Geological Survey of Canada locality number) - 29 (sample number) - 30 (slide number), 10.7 x 106.7 (grid reference of specimen), GSC 73864 (Geological Survey of Canada type number). In some cases there may be extra digits after the locality number but before the sample number, e.g., D-1014-JS-1-72-6-1. In this case, JS-1-72-6 refers to the name of the collector and the date of collection (see also Appendices 1 and 2).

All holotypes and figured specimens are in the collections of the Geological Survey of Canada, Ottawa, and each specimen has a unique type number, e.g., GSC 73727.

Specimens conforming to the original species description are not discussed but are listed in Table 10. This composite list of species includes *Spelaeotriletes pretiosus* var. *pretiosus* found only in the Horton Group. Descriptions are given of sixteen new species, three new varieties, and three new combinations. Five new forms are described but not named. Also discussed are four species with different size ranges than in the original descriptions, or with other minor differences. Two species are emended. The classification used is summarized in Table 11; it is a combination of various proposals made by previous workers, including Potonié and Kremp (1954), Dybová and Jachowicz (1957), Dettman (1963), and Neves and Owens (1966).

In each description of a new species, one holotype, and in most cases three figured specimens, have been illustrated in order to demonstrate the variability within a population.

TABLE 10

Composite list of species

Acanthotriletes hacquebardii Playford, 1964
Actinotodissus sp. A
Anapiculatisporites fundiensis sp. nov.
Auroraspora macra Sullivan, 1968
Auroraspora solisortus Hoffmeister, Staplin and Malloy, 1955
Biannulatisporites simplex Neville, 1973
Calamospora parva Guennel, 1958
Chomotriletes multivittatus Playford, 1978
Colatisporites decorus (Bharadwaj and Venkatachala) Williams, 1973
Convolutispora labyrinthea sp. nov.
Convolutispora mellita Hoffmeister, Staplin and Malloy, 1955
Convolutispora tessellata Hoffmeister, Staplin and Malloy, 1955
Convolutispora vermiformis Hughes and Playford, 1961
Crassispora trychera Neves and Ioannides, 1974
Cristatisporites submarginatus (Playford) comb. nov.
Densosporites columbaris sp. nov.
Dictyotriletes odontolophos sp. nov.
Discernisporites barssii sp. nov.
Discernisporites diaphanes sp. nov.
Discernisporites macromanifestus (Hacquebard) comb. nov.
Discernisporites micromanifestus (Hacquebard) Sabry and Neves, 1971
Eisenackidium playfordii sp. nov.
Elektoriskos sp. A
Grandispora spinosa Hoffmeister, Staplin and Malloy, 1955
Grandispora uncata (Hacquebard) Playford, 1971
Granulatisporites tuberculatus Hoffmeister, Staplin and Malloy, 1955
Granulatisporites sp. cf. *G. tuberculatus*
Ibrahimispores magnificus Neves, 1961
Knoxisporites literatus (Waltz) Playford, 1962
Knoxisporites probolos sp. nov.
Knoxisporites stephanephorus Love, 1960
Knoxisporites triradiatus Hoffmeister, Staplin and Malloy, 1955
Knoxisporites sp. A
Leiosphaeridia? scotia sp. nov.
Leiosphaeridia? sp. A
Leiotriletes inermis (Waltz) Ischenko, 1952
Leiotriletes ornatus Ischenko, 1956
Lycospora noctuina Butterworth and Williams, 1958 var. *noctuina*
Lycospora pusilla (Ibrahim) Schopf, Wilson and Bentall
"tendance B2" Somers, 1972
Micrhystridium? sp.
Microreticulatisporites hacquebardii sp. nov.
Neoraistrickia versiforma sp. nov.
Punctatisporites irrasus Hacquebard, 1957
Punctatisporites minutus Kosanke, 1950
Punctatisporites planus Hacquebard, 1957
Pustulatisporites multicapitis Bertelsen, 1972
Raistrickia baculosa Hacquebard, 1957
Raistrickia clavata Hacquebard emend. Playford, 1964
Raistrickia magdalena sp. nov.
Raistrickia nigra Love, 1960
Retusotriletes incohatus Sullivan, 1964a
Rugospora corporata Neves and Owens var. *verrucosa* Neville, 1968
Rugospora minuta Neves and Ioannides, 1974
Rugospora polyptycha Neves and Ioannides, 1974
Schopfipollenites acadiensis sp. nov.
Schopfites claviger Sullivan, 1968
Schulzospora bilunata sp. nov.
Scutulum trisupplementum sp. nov.
Secarisporites lobatus Neves, 1961
Secarisporites remotus Neves, 1961
Spelaeotriletes echinatus Hacquebard comb. nov. and emend.
Spelaeotriletes pretiosus (Playford) Neves and Belt emend. var. *pretiosus*
Spelaeotriletes pretiosus (Playford) Neves and Belt emend. var. *bellii* var. nov.
Spelaeotriletes pretiosus (Playford) Neves and Belt emend. var. *windsorensis* var. nov.
Spelaeotriletes tuberosus sp. nov.
Tricidarisporites arcuatus Neville, 1973
Vallatisporites ciliaris (Luber) Sullivan, 1964b
Vallatisporites verrucosus Hacquebard, 1957
Verrucosisporites morulatus (Knox) Smith and Butterworth, 1967
Verrucosisporites nitidus (Naumova) Playford, 1964
Verrucosisporites papulosus Hacquebard, 1957
Verrucosisporites verrucosus (Ibrahim) Ibrahim, 1933

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TABLE 11

Systematic classification used for palynomorphs illustrated in Plates 1-6 and recorded in Table 10

- Anteturma **SPORITES** H. Potonié, 1893
- Turma **TRILETES** Reinsch 1881, emend. Potonié and Kremp, 1954
- Suprasubturma **ACAMERATITRILETES** Neves and Owens, 1966
- Subturma **AZONOTRILETES** Luber, 1938
- Infraturma **LAEVIGATI** (Bennie and Kidston), 1956
  - *Calamospora parva* Guennel, 1958
  - *Leiotriletes inermis* (Waltz) Ischenko, 1952
  - *Leiotriletes ornatus* Ischenko, 1956
  - *Punctatisporites irrasus* Hacquebard, 1957
  - *Punctatisporites minutus* Kosanke, 1950
  - *Punctatisporites planus* Hacquebard, 1957
  - *Retusotriletes incohatus* Sullivan, 1964a
- Infraturma **APICULATI** (Bennie and Kidston) Potonié, 1956
- Subinfraturma **GRANULATI** Dybová and Jachowicz, 1957
  - *Granulatisporites tuberculatus* Hoffmeister, Staplin and Malloy, 1955
  - *Granulatisporites* sp. cf. *G. tuberculatus*
- Subinfraturma **NODATI** Dybová and Jachowicz, 1957
  - *Acanthotriletes hacquebardii* Playford, 1964
  - *Anapiculatisporites fundiensis* sp. nov.
  - *Pustulatisporites multicapitis* Bertelsen, 1972
  - *Tricidarisporites arcuatus* Neville, 1973
- Subinfraturma **BACULATI** Dybová and Jachowicz, 1957
  - *Ibrahimispores magnificus* Neves, 1961
  - *Neoraistrickia versiforma* sp. nov.
  - *Raistrickia baculosa* Hacquebard, 1957
  - *Raistrickia clavata* Hacquebard emend. Playford, 1964
  - *Raistrickia magdalena* sp. nov.
  - *Raistrickia nigra* Love, 1960
- Subinfraturma **VERRUCATI** Dybová and Jachowicz, 1957
  - *Schopfites claviger* Sullivan, 1968
  - *Verrucosisporites morulatus* (Knox) Smith and Butterworth, 1967
  - *Verrucosisporites nitidus* (Naumova) Playford, 1964
  - *Verrucosisporites papulosus* Hacquebard, 1957
  - *Verrucosisporites verrucosus* (Ibrahim) Ibrahim, 1933
- Infraturma **MURORNATI** Potonié and Kremp, 1954
  - *Convolutispora labyrinthea* sp. nov.
  - *Convolutispora mellita* Hoffmeister, Staplin and Malloy, 1955
  - *Convolutispora tessellata* Hoffmeister, Staplin and Malloy, 1955
  - *Convolutispora vermiformis* Hughes and Playford, 1961
  - *Dictyotriletes odontolophos* sp. nov.
  - *Microreticulatisporites hacquebardii* sp. nov.
- Infraturma **PSEUDOCINGULATI** Neves, 1961
  - *Secarisporites lobatus* Neves, 1961
  - *Secarisporites remotus* Neves, 1961
- Subturma **ZONOTRILETES** Waltz, 1935
- Infraturma **AURICULATI** (Schopf) Potonié and Kremp, 1954
  - *Scutulum trisupplementum* sp. nov.
- Infraturma **CINGULATI** (Potonié and Klaus) Dettman, 1963
  - *Knoxisporites literatus* (Waltz) Playford, 1962
  - *Knoxisporites probolos* sp. nov.
  - *Knoxisporites stephanephorus* Love, 1960
  - *Knoxisporites triradiatus* Hoffmeister, Staplin and Malloy, 1955
  - *Knoxisporites* sp. A
  - *Vallatisporites ciliaris* (Luber) Sullivan, 1964
  - *Vallatisporites verrucosus* Hacquebard, 1957
- Suprasubturma **LAMINATITRILETES** Smith and Butterworth, 1967
- Subturma **ZONOLAMINATITRILETES** Smith and Butterworth, 1967
- Infraturma **CRASSITI** (Bharadwaj and Venkatachala) emend. Smith and Butterworth, 1967
  - *Crassispora trychera* Neves and Ioannides, 1974
- Infraturma **CINGULICAVATI** Smith and Butterworth, 1967
  - *Cristatisporites submarginatus* (Playford) comb. nov.
  - *Densosporites columbaris* sp. nov.
  - *Lycospora noctuina* Butterworth and Williams, 1958 var. *noctuina*
  - *Lycospora pusilla* (Ibrahim) Schopf, Wilson and Bentall "tendance B2" Somers, 1972
- Suprasubturma **CAMERATITRILETES** Neves and Owens, 1966
- Subturma **SOLUTITRILETES** Neves and Owens, 1966
- Infraturma **DECORATI** Neves and Owens, 1966
  - *Spelaeotriletes pretiosus* (Playford) Neves and Belt emend. var. *pretiosus*
  - *Spelaeotriletes pretiosus* (Playford) Neves and Belt emend. var. *bellii* var. nov.
  - *Spelaeotriletes pretiosus* (Playford) Neves and Belt emend. var. *windsorensis* var. nov.
  - *Spelaeotriletes echinatus* Hacquebard comb. nov. and emend.
  - *Spelaeotriletes tuberosus* sp. nov.
- Subturma **MEMBRANATITRILETES** Neves and Owens, 1966
- Infraturma **CONTINUATI** Neves and Owens, 1966
  - *Discernisporites barssii* sp. nov.
  - *Discernisporites diaphanes* sp. nov.
  - *Discernisporites macromanifestus* (Hacquebard) comb. nov.
  - *Discernisporites micromanifestus* (Hacquebard) Sabry and Neves, 1971
  - *Grandispora spinosa* Hoffmeister, Staplin and Malloy, 1955
  - *Grandispora uncata* (Hacquebard) Playford, 1971
  - *Rugospora corporata* Neves and Owens var. *verrucosa* Neville, 1968
  - *Rugospora minuta* Neves and Ioannides, 1974
  - *Rugospora polyptycha* Neves and Ioannides, 1974
- Suprasubturma **PSEUDOSACCITRILETES** Richardson, 1965
- Infraturma **MONOPSEUDOSACCITI** Smith and Butterworth, 1967
  - *Schulzospora bilunata* sp. nov.
- Infraturma **TRILETISACCITI** Leschik, 1955
  - *Auroraspora macra* Sullivan, 1968
  - *Auroraspora solisortus* Hoffmeister, Staplin and Malloy, 1955
  - *Colatisporites decorus* (Bharadwaj and Venkatachala) Williams, 1973
- Turma **PLICATES (PLICATA** Naumova, 1937, 1939) Potonié, 1960
- Subturma **PRAECOLPATES** Potonié and Kremp, 1954
  - *Schopfipollenites acadiensis* sp. nov.
- Turma **ALETES** Ibrahim, 1933
  - *Chomotriletes multivittatus* Playford, 1978
- Group **ACRITARCHA** Evitt, 1963
  - *Actinotodissus* sp. A
  - *Eisenackidium playfordii* sp. nov.
  - *Elektoriskos* sp. A
  - *Michrystridium*? sp.
  - *Leiosphaeridia*? *scotia* sp. nov.
  - *Leiosphaeridia*? sp. A
- **Incertae sedis**
  - *Biannulatisphaerites simplex* Neville, 1973

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Anteturma SPORITES H. Potonié, 1893

Turma TRILETES Reinsch 1881, emend.
Potonié and Kremp, 1954

Suprasubturma ACAMERATITRILETES
Neves and Owens, 1966

Subturma AZONOTRILETES Luber, 1938

Infraturma APICULATI (Bennie and Kidston)
Potonié, 1956

Subinfraturma GRANULATI Dybová and Jachowicz, 1957

Genus *Granulatisporites*
(Ibrahim) Potonié and Kremp, 1954

Type species. *Granulatisporites granulatus* Ibrahim, 1933.

Granulatisporites sp. cf. *G. tuberculatus*

Plate 1, figure 9

Figured specimen. D-1384-29-30, 10.7 x 106.7, GSC 73844, macrofaunal Subzone D, Upper Windsor Group, Port Hood Island section Cape Breton Island, Nova Scotia, GSC locality D-1384.

Occurrence. Upper Windsor Group macrofaunal Subzone D. AT Zone.

Description. Rounded-triangular, sides convex, laesurae straight extending two thirds of radius. Ornament on distal surface of coni and tubercula 1 µm high, with basal diameter 1-2 µm; closely spaced; distance between elements rarely exceeds 1 µm. Ornament extends onto proximal surface, although contact area is unornamented. Exine approximately 1 µm thick.

Diameter. 49 µm (1 specimen).

Remarks. This species is similar to *Granulatisporites tuberculatus* Hoffmeister, Staplin, and Malloy, 1955, but differs in having convex margins.

Subinfraturma NODATI Dybová and Jachowicz, 1957

Genus *Anapiculatisporites* (Potonié and Kremp)
Smith and Butterworth, 1967

Type species. *Anapiculatisporites isselburgensis* Potonié and Kremp, 1954.

Anapiculatisporites fundiensis sp. nov.

Plate 1, figures 12-14

Holotype. D-1384-3-1, 42.0 x 108.6, GSC 73736, Pl. 1, fig. 12, macrofaunal Subzone B, Port Hood Island section, Cape Breton Island, Nova Scotia, GSC locality D-1384.

Figured specimens. D-1384-3-1, 41.7 x 105.6, GSC 73737, Pl. 1, fig. 13, D-1384-3-1, 42.0 x 102.0, GSC 73738, Pl. 1, fig. 14, macrofaunal Subzone B, Port Hood Island section, Cape Breton Island.

Occurrence. Lower Windsor Group macrofaunal Subzones A and B; Upper Windsor Group Subzones C to E; Windsor-Canso Group boundary beds. NS, AT and SM zones.

Diagnosis. Trilete spores, amb subtriangular, rounded convex sides, generally preserved as lateral compressions, in most specimens strong secondary folding is present. Laesurae simple, not always visible, extending to approximately three quarters of radius. Proximal surface laevigate, distal surface with small but variable ornament, consisting mainly of irregularly scattered narrow spinae, which occasionally have bulbous bases and acicular terminations. Occasional bacula with tapering terminations and rare coni may all occur in a single specimen. Height of elements variable within a single specimen; average height of elements 1 to 2 µm, maximum 5 µm; basal diameter of spinae, coni and bacula 0.5 µm or less; distance between elements varies from 0.5 to 3 µm. Exine thin, approximately 0.25 µm.

Diameter. 30 to 51 µm, mean 40 µm (20 specimens).

Remarks. Anapiculatisporites fundiensis may be distinguished from *Raistrickia magdalena* sp. nov. as it has an ornament consisting mainly of narrow spinae, rare bacula and rare coni, whereas *R. magdalena* has a stouter ornament consisting mainly of bacula with coni and echini; also the elements are less common. The exine of *A. fundiensis* is thinner than that of *R. magdalena. Schopfites delicatus* Higgs differs from *A. fundiensis* in that it has an ornament of closely spaced pila and fine bacula.

Derivation of name. Bay of Fundy, Nova Scotia.

Subinfraturma BACULATI Dybová and Jachowicz, 1957

Genus *Ibrahimispores* Artuz, 1957

Type species. *Ibrahimispores microhorridus* Artuz, 1957.

Ibrahimispores magnificus Neves, 1961

Plate 1, figure 16

Figured specimen. D-1534–KA21-1-3, 31.8 x 101.7, GSC 73740, Pl. 1, fig. 16, Windsor-Canso Group boundary beds, Baddeck, Cape Breton Island, Nova Scotia.

Occurrence. Windsor-Canso Group boundary beds. SM Zone.

Remarks. The two species *Ibrahimispores brevispinosus* and *I. magnificus* Neves are, as suggested by Neves, closely related; differentiation depends largely on the length of the spines and their density. In *I. brevispinosus*, the spines are 6-10 µm high and densely spaced, with 40 to 50 elements at the equatorial outline. The spine bases are 3-5 µm wide. In *I. magnificus*, the spines are 15-20 µm high and less densely set, so that elements of equal size could be placed between them and 15 to 20 elements occur at the equatorial margin. Spine bases are 3-8 µm wide.

Most specimens found in Atlantic Canada appear to occupy an intermediate position between these two species. The spines in some single specimens vary from 9-17 µm, although the majority are in the lower part of the size range and average approximately 10 µm. Thus, the spine lengths are in the upper part of the size range of *I. brevispinosus*, although individual spines may be above that range, and more similar to *I. magnificus*. The density of spines in most specimens is less than that of *I. brevispinosus*, but is closer to, if not slightly greater than, the spine density of *I. magnificus*. Bifurcation of the spines occurs occasionally and this feature is in common with *I. magnificus*. The spine bases on some elements are up to 10 µm wide, and are significantly wider than those of *I. brevispinosus*.

The specimens found in Atlantic Canada are therefore somewhat arbitrarily identified as *I. magnificus*, as they resemble it more closely than *I. brevispinosus*.

Genus *Neoraistrickia* Potonié, 1956

Type species. *Neoraistrickia truncatus* (Cookson) Potonié, 1956.

Neoraistrickia versiforma sp. nov.

Plate 1, figures 17-19

Holotype. D-1384-6-2, 37.0 x 102.5, GSC 73741, Pl. 1, fig. 17, macrofaunal Subzone B, Port Hood Island section, Cape Breton Island, Nova Scotia, GSC locality D-1384.

Figured specimens. R.O.M., IDM-3-3-2, 79 HG6, 35.7 x 97.3, GSC 73742, Pl. 1, fig. 18, and 10.5 x 107.6, GSC 73743, Pl. 1, fig. 19, Bassin aux Huîtres member of the Havre aux Maisons Formation of Sanschagrin (1964) (equivalent to the Upper Windsor Group).

Occurrence. Macrofaunal Subzone B of the Lower Windsor Group of the Port Hood Island section, Cape Breton Island, Nova Scotia; Upper Windsor Group (Bassin aux Huîtres member), Île Boudreau, and Magdalen Islands, Quebec. NS and AT zones.

Diagnosis. Trilete cavate spores. Amb rounded-triangular to triangular in shape, sides convex. Laesurae simple, straight, extending almost to equator. Exine laevigate, approximately 1.5 µm thick. Ornament on distal surface variable, consisting mainly of bacula, which sometimes bifurcate, and occasional coni and echini. Elements generally no higher than 4 µm, variable width no greater than 3 µm. Number of elements protruding at equator approximately 30 to 35; closely spaced, bases may coalesce.

Diameter. Excluding ornament, 20 to 43 µm, mean 32 µm (16 specimens).

Remarks. This species may be distinguished from other baculate species in the Windsor Group by its almost triangular shape and the variable nature of the predominantly baculate elements. It differs from *Acanthotriletes baculatus* Neves, 1960, which has a more widely spaced ornament and longer elements.

Derivation of name. Latin, *versiformis*, of different shapes.

Genus *Raistrickia* (Schopf, Wilson and Bentall) Potonié and Kremp, 1954

Type species. *Raistrickia grovensis* Schopf in Schopf, Wilson and Bentall, 1944.

Raistrickia baculosa Hacquebard, 1957

Plate 1, figure 23

Figured specimens. D-1534-KA-63-D-2, 34.0 x 101.7, GSC 73747, Pl. 1, fig. 23, Windsor-Canso Group boundary beds, near Baddeck, Cape Breton Island, Nova Scotia.

Occurrence. Upper Windsor Group and Windsor-Canso Group boundary beds. Lowermost part of "Green Oaks formation" (probably macrofaunal Subzone C) and "Watering Brook formation" (Windsor-Canso Group boundary beds), Stewiacke borehole SB-1, Hants County; Windsor-Canso Group boundary beds, near Baddeck, Cape Breton Island (D-1534-KA63-D, KA63-C and KA21). NS, AT and SM zones.

Description. Trilete cavate miospores amb irregularly oval to rounded-subtriangular. Laesurae simple, extend approximately three quarters of radius. Exine laevigate. Ornament of individual specimens variable, occurring mainly on distal surface. Consists of irregularly distributed and irregularly shaped bacula; apices sometimes truncate and mainly papillate, but sometimes rounded with less frequent, sometimes irregularly shaped, rugulae, which may bear small papillae at the crests; rare coni and echini also present; average height of ornament 4 to 5 µm, maximum 8.5 µm; distance between elements variable, some coalescing at base or widely spaced (up to 7 µm apart). Basal diameter very variable (2.5-11 µm). Most specimens preserved with slight lateral compression.

Diameter. 46 to 58 µm, mean 52 µm (11 specimens).

Remarks. The size range of the material described from the Horton Group by Hacquebard (1957) was 72 to 102 µm, and that by Playford (1964) was 64 to 91 µm. The specimens described here are smaller, but there are no other significant differences The reason for this size difference is not clear; it may in some way be related to the selective sorting and concentration during transportation by the wind, or the different processing techniques, or the unusual depositional geochemistry of the beds.

Raistrickia clavata Hacquebard emend. Playford, 1964

Plate 1, figure 24

Figured specimens. D-1384-21-1, 48.3 x 103.8, GSC 73748, Pl. 1, fig. 24, macrofaunal Subzone C, Port Hood Island section, Cape Breton Island, Nova Scotia.

Occurrence. Lower and Upper Windsor Group and Windsor-Canso Group boundary beds. NS and AT zones.

Description. Specimens identical in size and morphology to those described by Playford (1964) occur, but in addition there are individuals smaller than the size range of 48 to 85 µm given in the original description. The smallest specimen seen was 30 µm.

Remarks. The smaller specimens found in the Windsor beds and their lateral equivalents have similar sculptural diversity to *Raistrickia clavata* although the size range is similar to *Raistrickia accincta* Playford and Helby, 1968. However *R. accincta* has more sculptural diversity than *R. clavata*. As in *R. baculosa*, the reason for the smaller size range of *R. clavata* is not clear, but it may also be the product of the selective sorting and concentration during transportation by the wind, or the different processing techniques, or the unusual depositional geochemistry of the beds.

Raistrickia magdalena sp. nov.

Plate 1, figures 20-22

1980 *Anaplanisporites* sp. Utting, Pl. 2, fig. 3.

Holotype. D-1384-32-1, 37.3 x 102.2, GSC 73744, Pl. 1, fig. 20, macrofaunal Subzone D, Port Hood Island section, Cape Breton Island, Nova Scotia, GSC locality D-1384.

Figured specimens. D-1014-JS-1-72-6-1, 37.6 x 94.9, GSC 73745, Pl. 1, fig. 21; and D-1014-JS-1-72-6-2, 32.0 x 100.2, GSC 73746, Pl. 1, fig. 22, macrofaunal Subzone D, Cape Dauphin section, Cape Breton Island, Nova Scotia

Occurrence. Upper Windsor Group and Windsor-Canso Group boundary beds. Macrofaunal Subzones C and D of Port Hood Island section; macrofaunal Subzone D of Cape Dauphin section, Cape Breton Island; uppermost part of "Green Oaks formation" (probably macrofaunal Subzone E), Stewiacke borehole SB-1, Hants County; macrofaunal Subzone E, Kennetcook Limestone Member of Windsor type section, Windsor; "Watering Brook formation" (Windsor-Canso Group boundary beds), Stewiacke borehole SB-1, Hants County; Upper(?) Windsor Group (D-1010-JS-32-72-4 and JS-32-72-5), Knoydart Point section, Antigonish County; Windsor-Canso Group boundary beds, near Baddeck, Cape Breton Island (D-1534-KA63-D, KA63-C and KA21). NS, AT and SM zones.

Diagnosis. Trilete, cavate miospores, shape subtriangular to subcircular to oval, sides convex. Laesurae not always visible, extending from two thirds of radius to equatorial margin; exine sometimes slightly darker in contact areas. Exine moderately thick (approximately 2 µm) and laevigate, lateral compression of specimens frequent, secondary folds usually present. On distal surface, ornament consists of irregularly spaced bacula with broad based coni and echini, all elements may occur on one specimen; maximum height of processes 2.5 µm, average 1.5 µm; space between elements variable, but generally not less than 2.5 µm. Ornament in some specimens may extend slightly on to equatorial margin of proximal surface.

Diameter. In view of the unequal shape of most specimens, as a result of folding during preservation, only the maximum diameter was measured. Diameter 40 to 54 µm, mean 47 µm (15 specimens).

Remarks. This species has been included in the genus *Raistrickia* because the ornament consists mainly of bacula, although coni and echini may also occur.

Derivation of name. After the Magdalen Islands, Quebec. Latin noun, *Magdalena*.

Subinfraturma VERRUCATI Dybová and Jachowicz, 1957

Genus *Verrucosisporites* (Ibrahim) emend
Smith and Butterworth, 1967

Type species *Verrucosisporites verrucosus* (Ibrahim) Ibrahim, 1933.

Verrucosisporites papulosus Hacquebard, 1957

Plate 1, figures 26-29

Figured specimens. D-1384-3-3, 35.0 x 99.4, GSC 73750, Pl. 1, fig. 26, macrofaunal Subzone B, Port Hood Island section, Cape Breton Island, Nova Scotia, D-1384-3-1, 39.5 x 96.6, GSC 73751, Pl. 1, fig. 27, and D-1384-3-1, 44.1 x 94.3, GSC 73752, Pl. 1, fig. 28, macrofaunal Subzone B, Port Hood Island section, Cape Breton Island, Nova Scotia; C-097708-SEM 131, GSC 73753, Pl. 1, fig. 29, Upper Windsor, Knoydart Point, Nova Scotia.

Occurrence. Lower and Upper Windsor Group. Macrofaunal Subzones A to E, Windsor-Canso Group boundary beds. Subzones B and D, Port Hood Island section, Cape Breton Island. The "Macumber formation" (macrofaunal Subzone A), and the "Watering Brook formation" (Windsor-Canso Group boundary) in Stewiacke borehole SB-1, Hants County, Nova Scotia. NS, AT and SM zones.

Description. Subcircular in shape; secondary arcuate folding common, producing irregular, oval shape. Laesurae variable, simple, straight, and up to 18 µm long. Ornament on proximal and distal surfaces consists of small verrucae of irregular shape and size with a subcircular to irregular polygonal outline. Diameter of verrucae varies from 0.25 to 1.5 µm and height from 0.25 to 0.5 µm. Space between verrucae small (generally less than 0.25 µm).

Diameter. 28 to 48 µm, mean 35 µm (20 specimens).

Remarks. The forms described here resemble specimens of *Verrucosisporites papulosus* Hacquebard, 1957, from the Horton Group, but the latter are larger (50-62 µm) and the verrucae are generally slightly larger, higher, and more widely spaced. Since the differences observed may be due only to the smaller size of the forms described here, they may not be of taxonomic significance. Consequently no new species has been proposed. A similar phenomenon was noted with *Raistrickia baculosa* and *R. clavata*. *Cyclogranisporites commodus* Playford, 1963 has a smaller ornament of closely spaced grana, but is otherwise not markedly different from small specimens of *Verrucosisporites papulosus*.

Infraturma MURORNATI Potonié and Kremp, 1954

Genus *Convolutispora* Hoffmeister,
Staplin and Malloy, 1955

Type species. *Convolutispora florida* Hoffmeister, Staplin and Malloy, 1955.

Convolutispora labyrinthea sp. nov.

Plate 2, figures 5-7

Holotype. D-1384-7-1, 38.5 x 98.6, GSC 73758, Pl. 2, fig. 5, Port Hood Island section, Cape Breton Island, Nova Scotia, GSC locality D-1384.

Figured specimens. D-1384-21-1, 37.3 x 100.4, GSC 73759, Pl. 2, fig. 6, same locality as holotype; D-1384-16-1, 41.6 x 100.2, GSC 73760, Pl. 2, fig. 7, same locality as holotype.

Occurrence. Present throughout the Windsor Group and the Windsor-Canso Group boundary beds and lateral equivalents. NS, AT and SM zones.

Diagnosis. Trilete spore, amb margin irregular, but overall shape semicircular to oval to rounded subtriangular. Laesurae simple, straight, extend almost to equator. Ornament of close, but occasionally loosely packed low muri on proximal and distal surfaces. Muri generally no higher than 2 µm, although sometimes less; anastomosing and terminating irregularly, producing irregular and variable outlines with frequent indentation; width very variable but generally 2 µm to 4 µm. Vermiculae generally 0.5 µm to 1 µm wide, with a variable labyrinth-like pattern. Exine approximately 1.5 µm thick.

Diameter. 40 µm to 62 µm, mean 48 µm (18 specimens).

Remarks. The low, irregularly shaped, relatively narrow muri distinguish these specimens from other described species of *Convolutispora*. *Convolutispora florida* Hoffmeister, Staplin and Malloy, 1955 resembles *C. labyrinthea*, but has coarser muri. *Convolutispora* sp. A Hoffmeister, Staplin and Malloy, 1955 appears to be similar to *Convolutispora labyrinthea*, and may belong to the same species. However, it is difficult to be certain from the single figured specimen and the description given.

Derivation of name. Latin, *labyrinthea*, labyrinth.

Genus *Dictyotriletes* (Naumova)
Smith and Butterworth, 1967

Type species. *Dictyotriletes bireticulatus* (Ibrahim) Potonié and Kremp, 1954.

Dictyotriletes odontolophos sp. nov.

Plate 2, figures 11-13

Holotype. D-1384-29-23, 29.5 x 99.6, GSC 73764, Pl. 2, fig. 11, macrofaunal Subzone B, Port Hood Island section, Cape Breton Island, Nova Scotia, GSC locality D-1384.

Figured specimens. D-1384-6-2, 34.6 x 99.5, GSC 73765, Pl. 2, fig. 12, macrofaunal Subzone B, Port Hood Island section; D-1014-3S-1-72-6-7, 31.8 x 99.5, GSC 73766, Pl. 2, fig. 13, macrofaunal Subzone D, Cape Dauphin, Cape Breton Island, Nova Scotia.

Occurrence. Lower and Upper Windsor Group. Macrofaunal Subzones B, C, and D, Port Hood Island section, Cape Breton Island, Nova Scotia; macrofaunal Subzone D, Cape Dauphin section, Cape Breton Island, Nova Scotia; Windsor-Canso Group boundary beds near Baddeck, Cape Breton Island, Nova Scotia. NS, AT and SM zones.

Diagnosis. Trilete spore, amb with irregular margin, but overall shape subcircular to oval. Laesurae simple and straight, extending from one half to three quarters of radius, sometimes obscured by muri. Muri occur on distal surface, up to 5 µm high, 8.5 µm long and 1.25 µm wide, forming polygonal lacuna bordered by variable number of muri (6 or less); longest diameter of lacuna 20 µm. At intersections of muri apparent projections formed. Crests of muri with ornament of grana, coni, stout pila, and short bacula producing crenulated outline. Height of elements varies, not exceeding 2.5 µm; basal diameter also varies, not exceeding 5 µm. Number of elements between intersections of muri varies with length of muri, generally not exceeding eight. Exine approximately 1 µm thick.

Diameter. 36 to 49 µm, mean 41 µm (14 specimens).

Remarks. *Dictyotriletes odontolophos* resembles *Dictyotriletes sagenoformis* Sullivan, 1964, although *D. sagenoformis* is larger (58-73 µm) and has no ornament on the crests of the muri. *Reticulatisporites*? *fimbriatus* Winslow, 1962 is similar to *Dictyotriletes odontolophos*, but *R. fimbriatus* is larger (69-115 µm), the muri are higher, and the crests of the muri have a more prominent ornament. *Dictyotriletes pactilis* Sullivan and Marshall, 1966 differs from *D. odontolophos* by its higher muri, the crests of which have no ornament. *Dictyotriletes fragmentimurus* Neville, 1973 has muri that are not continuous, but are broken and disrupted.

Derivation of name. Greek, *odontos*, teeth; Greek, *lophos*, crest, ridge.

Genus *Microreticulatisporites* (Knox)
Potonié and Kremp, 1954

Type species. *Microreticulatisporites lacunosus* (Ibrahim) Knox, 1950.

Microreticulatisporites hacquebardii sp. nov.

Plate 2, figures 14-16

Holotype. D-1384-16-1, 32.7 x 100.3, GSC 73767, Pl. 2, fig. 14, macrofaunal Subzone C, Port Hood Island section, Cape Breton Island, Nova Scotia, GSC locality D-1384.

Figured specimens. R.O.M. Heatherton-2-9-78-PB-25-2, 33.4 x 96.0, GSC 73768, Pl. 2, fig. 15, macrofaunal Subzone A, St. George's Bay, Newfoundland; D-1384-3-1, 33.0 x 110.0, GSC 73769, Pl. 2, fig. 16, macrofaunal Subzone B, Port Hood Island section, Cape Breton Island, Nova Scotia.

Occurrence. Macrofaunal Subzone A, Ship Cove Formation, southwestern Newfoundland. Macrofaunal Subzone B of Lower Windsor Group, and macrofaunal Subzones C and D of Upper Windsor Group, Port Hood Island section, Cape Breton Island, Nova Scotia. NS and AT zones.

Diagnosis. Trilete spore, outline triangular, sides concave. Laesurae simple, straight, extend almost to equator. Sculpture of lacunae with a regular distribution on distal surface, but irregular distribution on proximal surface. Lacunae subcircular to elliptical; long axis up to 1.0 µm, short axis approximately 0.25 to 0.5 µm. Microreticulations between laesurae 1.0 to 2.0 µm across, generally laevigate. Distal surface of some specimens with scattered verrucae with basal diameter up to 1.5 µm, height of 1 µm. Exine approximately 1.5 µm thick.

Diameter. 36 to 45 µm, mean 39 µm (15 specimens).

Remarks. The specimens described here are similar in many respects to *Microreticulatisporites concavus* Butterworth and Williams, 1958, but in *M. concavus* the lacunae are larger (approximately 2 µm). The lacunae are small in *M. hacquebardii* (up to 1 µm) and on some specimens foveolae may be a more appropriate descriptive term for the sculpture. However, the specimens have not been included in *Foveosporites* Balme, 1957, as this genus is described as being circular to rounded triangular.

Derivation of name. After P.A. Hacquebard, Geological Survey of Canada, in recognition of his significant contribution to the Carboniferous stratigraphy and coal geology of Atlantic Canada.

Subturma ZONOTRILETES Waltz, 1935

Infraturma AURICULATI (Schopf, 1938) Potonié and Kremp, 1954

Genus *Scutulum* Felix and Burbridge, 1967

Type species. *Scutulum pusilum* Felix and Burbridge, 1967.

Scutulum trisupplementum sp. nov.

Plate 2, figures 19-22

Holotype. D-1014-3S-1-72-6-7, 33.5 x 100.3, GSC 73772, Pl. 2, fig. 19, macrofaunal Subzone D, 1.0 µm below carbonate at base of macrofaunal Subzone E, Knoydart, Nova Scotia.

Figured specimens. D-1014-3S-1-72-6-1, 40.6 x 105.3, GSC 73773, Pl. 2, fig. 20, same sample as holotype; D-1014-3S-1-72-6-7, 44.7 x 93.8, GSC 73774, Pl. 2, fig. 21, same sample as holotype; D-1384-27-1, 41.8 x 102.1, GSC 73775, Pl. 2, fig. 22, macrofaunal Subzone D, Port Hood Island section, Cape Breton Island, Nova Scotia.

Occurrence. Lower and Upper Windsor Group macrofaunal Subzones B, C and D, Port Hood Island section and Cape Dauphin section, Cape Breton Island, Nova Scotia; "Green Oaks formation", macrofaunal Subzone E, Stewiacke borehole SB-1, Nova Scotia; Bassin aux Huîtres Member, Magdalen Islands, Quebec. NS and AT zones.

Diagnosis. Trilete, shape rounded triangular, sides convex, sometimes wavy in outline. Laesurae straight, extend approximately seven eighths of spore radius; terminations of laesurae often slightly open. Thin labra (0.5 µm) on some specimens. Exine on proximal surface with triangular-shaped thickened area, apices of triangle terminate close to spore apices. Thickened exinal projections 5 to 8 µm wide and 5 to 7 µm long at apices; tips may coincide or almost reach equator enveloping laesurae terminations. Sides of triangle straight to convex, running subparallel to spore body. In some specimens, exine thins within triangular thickened area, producing well defined inner triangle of thinner exine. Distance between midpoint of interapical sides of spore and sides of triangle of thickened exine 6 to 8.5 µm. Spore exine in nonthickened parts laevigate to finely punctate; in thickened area, punctate. Exine approximately 3.5 µm thick at equatorial margin.

Diameter. 31 to 48 µm, mean 40 µm (20 specimens).

Remarks. Scutulum trisupplementum differs from *S. pusillum* in having a relatively larger area of thickened exine, which thins again toward the centre of the spore, and is triangular, whereas in *S. pusillum* it is subtriangular to rounded.

Derivation of name. Latin, *tria*, three; Latin, *supplementum*, reinforcement.

Infraturma CINGULATI (Potonié and Klaus) Dettman, 1963

Genus *Knoxisporites* (Potonié and Kremp) Neves, 1961

Type species. *Knoxisporites hageni* Potonié and Kremp, 1954.

Knoxisporites probolos sp. nov.

Plate 2, figures 24-27

1980 *Secarisporites? remotus* Utting, Pl. 2, fig. 4.

Holotype. D-1384-16-1, 44.4 x 95.7, GSC 73777, Pl. 2, fig. 24, macrofaunal Subzone C, Port Hood Island section, Cape Breton Island, Nova Scotia.

Figured specimens. D-1384-27-1, 39.3 x 94.4, GSC 73778, Pl. 2, fig. 25, tetrad, macrofaunal Subzone D, Port Hood Island section, Cape Breton Island, Nova Scotia; D-1477-58-5-1, 35.7 x 103.0, GSC 73779, Pl. 2, figs. 26, 27 (tetrad), Havre Aubert, Magdalen Islands, Quebec.

Occurrence. Lower and Upper Windsor Group and Windsor-Canso Group boundary beds. Macrofaunal Subzone B, Havre Aubert, Magdalen Islands. Macrofaunal Subzones C and D, Port Hood Island section, Cape Breton Island, Nova Scotia; lowermost and uppermost parts of the "Green Oaks formation" (probably macrofaunal Subzones C and E) and "Watering Brook formation" (Windsor-Canso boundary beds), Stewiacke borehole SB-1, Hants County; macrofaunal Subzone D, Cape Dauphin section, Cape Breton Island, Nova Scotia; the Windsor-Canso Group boundary beds in boreholes Noranda 4 and Noranda 12, Lake Enon, Cape Breton Island, and the Windsor-Canso Group boundary beds, near Baddeck, Cape Breton Island, Nova Scotia. NS, AT and SM zones.

Diagnosis. Trilete spores. Exine laevigate to finely punctate. Laesurae straight, extending almost to equator; bordered by labra 1 µm wide. Outline irregular, overall shape subcircular with frequent indentations, resulting from expansion of exoexine (approximately 0.25 µm thick) at margin of interapical area of subtriangular spore body into three, lobate outgrowths, up to 9.5 µm high. Rounded subtriangular, oval, or circular ring of thickening on distal surface of spore, approximately halfway between centre and margin of spore. Width of ring varies within and between specimens, generally 5 to 12 µm wide; edges irregular to lobate to smooth. Within ring, exine thinner, forming depression containing lobate thickening of varying shape and dimension in some specimens. Small, crowded, lobate outgrowths, generally of variable size on single specimen (no more than 5 µm across, from 1 to 12 µm high), on distal surface, between base of three lobate, lateral outgrowths and ring of exinal thickening. Some outgrowths verrucose in shape, others baculose. Exine laevigate to finely punctate.

Diameter. 39 to 45 µm, mean 40 µm (12 specimens).

Remarks. This species was assigned to *Knoxisporites* Potonié and Kremp, 1954 on the basis of the ring of exinal thickening around the distal pole. *Secarisporites remotus* Neves, 1961 resembles *Knoxisporites probolos*, but lacks a distal ring of exinal thickening, and normally has more than one lobate outgrowth in each interradial area. *Knoxisporites probolos* is not unlike *Knoxisporites disjunctus* Neville, comb. nov., which is discussed in the following section where a new combination is formally proposed. *Knoxisporites probolos* is significantly larger than *K. disjunctus*, which has a size range of 21 to 29 μm. On *K. probolos*, the distal ornament between the ring of exinal thickening and the base of the lobate outgrowths consists of lobate projections, which vary considerably in shape and size; *K. disjunctus* possesses only rugulae.

Knoxisporites probolos resembles *K. stephanephorus* Love, 1960 by having a ring of thickening on the distal surface that may contain a lobate outgrowth within its confines, but *K. probolos* differs in that it has three lobate outgrowths of the interapical area of the spore body, whereas *K. stephanephorus* does not. There may, however, be a close connection between these species, and both appear at the same stratigraphic horizon (macrofaunal Subzone A) of the Windsor Group; neither occurs in the Horton Group. *Knoxisporites probolos* occurs in the Windsor Group often in the form of a tetrad.

Derivation of name. Greek, *probolos*, a projection or prominence.

Knoxisporites disjunctus (Neville) comb. nov.

1973 *?Rotaspora disjuncta* Neville, p. 37-38, Pl. 1, figs. 22 and 23.

Holotype. Neville (in Neves et al., 1973), Pl. 1, figs. 22 and 23, housed in the micropaleontology collection of the Department of Geology, University of Sheffield.

Type locality. Sample F66; seatearth 135 feet (41.15 m) below the cornstone, which varies from 0-13 feet (0-3.96 m) in thickness, exposed in the coast section on the NE side of the fault in West Bay, Pittenweem, east Fife Coast, Scotland.

Diagnosis. (Neville, 1973, in Neves et al., 1973). "Spores radial; trilete. Suturae straight, extending to or almost to the spore body margin and either simple or accompanied by narrow raised tecta. Spore body subcircular to triangular with slightly or strongly convex sides. The proximal surface of the spore body is either laevigate or shows variations in exine thickness. The distal surface most typically possesses a thickened ring with a thickened polar boss. The ring may be irregular and disrupted and the boss may even be joined to it. In addition there may be irregular thickenings of the exine and irregular rugulae which extend on to the equatorial extension of the exine. Rarely, the thickened boss is absent and even more rarely the distal ornament consists simply of irregular rugulae. The equatorial extension is widest interradially, reduced or absent at the apices. It is laevigate apart from the distal rugulae which may extend on to it and interradially may reach 4 μm in width but at its widest point it may be as narrow as 1.5 μm. Rarely there is an embayment in the equatorial extension in an interradial region."

Remarks. As noted by Neville, *?Rotaspora disjuncta* may superficially resemble *Knoxisporites stephanephorus* Love, 1960, but it is generally smaller (21-29 μm) and possesses an equatorial extension, which is widest interradially. He considered it more appropriate to assign the species to *Rotaspora* Schemel, 1950, which possesses a similar equatorial extension, but which, at its periphery, has a narrow rim; this rim does not appear to be present on *?Rotaspora disjuncta*. In the author's view, the presence of a distal band of exinal thickening along with the central boss of thickened exine suggests that *?R. disjuncta* has more in common with *Knoxisporites stephanephorus* than any described species of *Rotaspora*. It would therefore appear more appropriate to transfer *?R. disjuncta* to *Knoxisporites disjuncta*.

Occurrence. Recorded by Neves et al. (1973) as occurring in their Concurrent Range zones TC, NM and VF of middle to late Viséan age.

Knoxisporites sp. A

Plate 3, figure 3

Figured specimen. D-1384-29-30, 22.2 x 96.5, GSC 73845, macrofaunal Subzone D, Upper Windsor Group, Port Hood Island section, Cape Breton Island, Nova Scotia.

Occurrence. Upper Windsor Group, macrofaunal Subzone D. AT Zone.

Description. Overall outline subcircular, with three main interapical projections, occasional minor projections and indentations at equator. Exoexine approximately 0.25 μm thick, laevigate. Inner body rounded subtriangular, laevigate, intexine approximately 0.75 μm thick. Laesurae extend to margin of inner body; labra approximately 1 μm wide, faint *curvaturae imperfectae*. Distal surface at polar axis has triangular shaped area of thickened exine. At apices, thickened exine tapers, forming three elongate projections with bulbous tips. These may slightly overlap equatorial margin at mid-point of interapical area. Projections about 7 μm wide at narrowest point, expanding to approximately 4 μm. Other minor lobate to verrucate projections may occur at margins of triangular region of exinal thickening.

Diameter. 54 μm (1 specimen).

Suprasubturma LAMINATITRILETES
Smith and Butterworth, 1967

Subturma ZONOLAMINATITRILETES
Smith and Butterworth, 1967

Infraturma CRASSITI Bharadwaj and Venkatachala emend.
Smith and Butterworth, 1967

Genus *Crassispora* Bharadwaj emend.
Sullivan, 1964

Type species. (by original designation) *Crassispora ovalis* Bharadwaj, 1956. According to Smith and Butterworth (1967, p. 237), *C. ovalis* is a junior synonym of *C. kosankei* (R. Potonié and Kremp) Bharadwaj, 1957.

Crassispora trychera Neves and Ioannides, 1974

Plate 3, figures 6-8

Figured specimens. D-1384-10-1, 35.3 x 93.5, GSC 73783, Pl. 3, fig. 6, macrofaunal Subzone B, Port Hood Island section, Cape Breton Island, Nova Scotia; C-097710-1, 43.7 x 101.8, GSC 73785, Pl. 3, fig. 7 and C-097710-1, 11.7 x 101.3, GSC 73786, Pl. 3, fig. 8, Upper Windsor(?) Group, Knoydart Point, Antigonish County.

Occurrence. Lower and Upper Windsor Group and Windsor-Canso Group boundary beds. NS, AT and SM zones.

Remarks. *Crassispora trychera* is abundant in most samples and although many specimens closely resemble the illustrations and description of Neves and Ioannides (1974), there are a number that differ (see Pl. 3, figs. 7, 8). These differences show continuous variation in a single sample and are essentially the result of variation in the thickness of the intexine and exoexine from one specimen to another along with variations in the ornament which, as stated by Neves and Ioannides (1974), is close or sparse, with bald areas frequently present.

The dimensions of most specimens fall within the size range of the original description (48-67 µm), although some specimens as small as 42 µm occur.

Some specimens of *Crassispora trychera* that have sparse ornamentation may superficially resemble *Auroraspora macra* Sullivan, or the closely related species *Colatisporites decorus* (Bharadwaj and Venkatachala) Williams.

Infraturma CINGULICAVATI Smith and Butterworth, 1967

Genus *Cristatisporites* (Potonié and Kremp) emend. Butterworth et al., 1964

Type species. *Cristatisporites indignabundus* (Loose) Potonié and Kremp, 1954.

Cristatisporites submarginatus (Playford) comb. nov.

Plate 3, figure 9

1964 *Dictyotriletes submarginatus* Playford, p. 29-30; Pl. 8, figs. 9-13.

Figured specimen. D-1384-3-1, 29.7 x 108.7, GSC 73787, Pl. 3, fig. 9, macrofaunal Subzone B, Port Hood Island section, Cape Breton Island, Nova Scotia.

Occurrence. Lower and Upper Windsor Group. NS, AT and SM zones.

Remarks. Playford (1971) compared *Dictyotriletes submarginatus* to *Cristatisporites colliculus* Playford, 1971, but concluded that the former is not two layered and has a lower size range and rugulate-reticulate sculpture. However, in the Windsor Group, well preserved specimens, which otherwise are identical to the illustrations and description of *Dictyotriletes submarginatus*, are two layered. Thus, it seems more appropriate to transfer this species to *Cristatisporites*.

Genus *Densosporites* (Berry) Butterworth, Jansonius, Smith, and Staplin, 1964

Type species. *Densosporites covensis* Berry, 1937.

Densosporites columbaris sp. nov.

Plate 3, figures 10-13

1967 *Densosporites variomarginatus* Playford, in Barss, 1967, Pl. V, fig. 13.

Holotype. GSC plant locality 1659-1, 36.4 x 101.4, GSC 73788, Pl. 3, fig. 10, undifferentiated Windsor Group, Frenchvale Brook, Balls Creek, Northwest Arm of Sydney Harbour, Cape Breton Island, Nova Scotia.

Figured specimens. C-097701-2, borehole K112, 232.17 m, 49.2 x 103.8, GSC 73789, Pl. 3, fig. 11, Lower Windsor Lake Enon, Cape Breton Island, Nova Scotia; C-097710-1, 20.0 x 97.3, GSC 73790, Pl. 3, fig. 12, Upper Windsor, Knoydart Point, Nova Scotia; C-097708-SEM 129, GSC 73791, Pl. 3, fig. 13, Upper Windsor, Knoydart Point, Nova Scotia.

Occurrence. Lower and Upper Windsor Group. Macrofaunal Subzone A; sample D-1370-98-3 North Gut St. Anns, Cape Breton Island, Nova Scotia; sample D-1373-106-6, North Shore, Cape Breton Island, Nova Scotia; sample D-1380-116-3, Broad Cove River, Lake Ainslie, Cape Breton Island, Nova Scotia. Macrofaunal Subzone B, sample D-1014-JS-1-72-0-30 from Cape Dauphin section, Cape Breton Island, Nova Scotia. Macrofaunal Subzones C and D, Port Hood Island section, Cape Breton Island, Nova Scotia. Also present in sample GSC plant locality 1659 from undifferentiated Windsor Group, Frenchvale Brook, Balls Creek, Northwest Arm of Sydney Harbour, Cape Breton Island, Nova Scotia. NS and AT zones.

Diagnosis. Spores radial trilete; amb rounded subtriangular to oval, almost parallel to body outline. Laesurae not often clearly visible due to corrosion of proximal surface; appear approximately straight, extending almost to margin of body, but not on to cingulum; accompanied by labra up to 1 µm high. Proximal surface apparently very thin, rarely present; some specimens occasionally have laevigate to finely punctate remnants of proximal surface near cingulum (Pl. 3, fig. 11). Distal surface with ornament of grana (up to 1.25 µm in diameter), occasionally rounded verrucae of varying sizes, up to 3.5 µm in diameter, but generally no higher than 1 µm. Grana and verrucae closely spaced; some specimens with negative reticulum produced. Cingulum smooth to slightly serrated, with ornament of rare, scattered grana and pila up to 1.25 µm high. Width of cingulum varies from 6 to 17 µm, width varying from 3 to 4 µm in a single specimen.

Diameter. 57 to 95 µm, mean 77 µm (17 specimens).

Remarks. *Densosporites variomarginatus* Playford, 1962 differs from *D. columbaris* in having a laevigate spore body and a cingulum with a distinctly radiating or striated appearance. *Densosporites pseudoannulatus* Butterworth and Williams, 1958 differs from *D. columbaris* in that it is smaller (33-55 µm) and the spore body has a finely granular ornament. In addition, the cingulum of *D. pseudoannulatus* is smooth to slightly spinose, whereas that of *D. columbaris* has scattered grana and pila.

Derivation of name. Latin, *columbaris*, collar.

Suprasubturma CAMERATITRILETES Neves and Owens, 1966

Subturma SOLUTITRILETES Neves and Owens, 1966

Infraturma DECORATI Neves and Owens, 1966

Genus *Spelaeotriletes* Neves and Owens, 1966

Type species. *Spelaeotriletes triangulus* Neves and Owens, 1966.

Spelaeotriletes echinatus Hacquebard comb. nov. and emend.

Plate 4, figures 9-12

1957 *Grandispora echinata* Hacquebard, p. 317, Pl. 3, fig. 17.

Holotype. D-1384-3-1, 46.5 x 107.8, GSC 73807, Pl. 4, fig. 9, macrofaunal Subzone B, Port Hood Island section, Cape Breton Island, Nova Scotia.

Figured specimens. D-1384-3-1, 33.2 x 103.1; GSC 73808, Pl. 4, fig. 10, D-1384-3-4, 34.0 x 94.3, GSC 73809, Pl. 4, fig. 11 and fig. 12, macrofaunal Subzone B, Port Hood Island section, Cape Breton Island, Nova Scotia.

Occurrence. Lower Windsor Group. Macrofaunal Subzone A, North Gut St. Anns, Cape Breton Island; "MacDonald Road formation" (macrofaunal Subzone A), Stewiacke borehole SB-1, Hants County, Nova Scotia; macrofaunal Subzone B, Port Hood Island section, Cape Breton Island, Nova Scotia. Mollichignick Member, Robinsons River Formation, macrofaunal subzone uncertain, presence of spores suggests lower beds may be correlated with the Lower Windsor Group and the upper beds with the Upper Windsor Group (Appendix 3, SW Newfoundland, section C). NS and AT zones.

Diagnosis. Trilete camerate miospores, amb rounded subtriangular, but secondary folding during preservation generally produces an irregular shape; sides convex. Outline of inner sac fairly well defined, often more or less parallel to spore outline; thickness of intexine approximately 0.25 µm; radius of inner sac generally two thirds to four fifths that of total spore radius. Some specimens with eccentric displacement of inner sac relative to outer sac. Trilete rays extending almost to margin of inner sac, associated folds of outer sac, up to 5 µm high, almost reaching equator, sinuous in outline. *Curvaturae imperfectae* present. Apical papillae sometimes visible, located approximately 6 µm from centre with diameter of 4 to 5 µm. Outer sac infragranulate; exoexine approximately 2 µm thick. Ornament, mainly on distal surface, consisting predominantly of galeae, coni and occasional pila; tips of galeae sometimes with filiform processes up to 2.5 µm long. Ornament fairly regularly spaced, elements generally less than 2.5 µm apart, height 3.5 µm or less (Pl. 4, fig. 12). Occasional elements on proximal equatorial region, especially in radial position.

Diameter. Overall 65 to 87 µm, mean 77 µm; inner sac 46 to 70 µm, mean 60 µm (15 specimens).

Remarks. *Spelaeotriletes echinatus* may be distinguished from *S. pretiosus* var. *bellii*, *S. pretiosus* var. *pretiosus* and *S. pretiosus* var. *windsorensis* by its ornament being dominated by galeae, coni and occasional pila, whereas the latter specimens have mainly rounded verrucae, although other elements including grana, coni, spinae, echini, galeae, pila and bacula may be present in small numbers.

Spelaeotriletes pretiosus (Playford) Neves and Belt emend.

1964 *Pustulatisporites pretiosus* Playford, p. 19-20, Pl. 4, figs. 5-7, Pl. 5, fig. 1, Textfig. 1a.

1970 *Spelaeotriletes pretiosus* (Playford) Neves and Belt, p. 1241.

Discussion. Neves and Owens (1966) suggested that *Pustulatisporites pretiosus* Playford, 1964 may be assigned to *Spelaeotriletes*, but no formal combination was made. Neves and Belt (1970, p. 1241) informally listed *Spelaeotriletes pretiosus* (Playford) nov. comb; however, no basionym was indicated, nor was there direct reference to the author and original publication, with page or plate reference and date, as recommended by the International Code of Botanical Nomenclature (1978, article 33.2). This information has now been given above.

Playford (1964) mentioned in the text of his paper the fact that a mesosporoid is occasionally perceptible as an ill defined, darker central body. Owens' examination of the type specimen and other representatives of the species (in Neves and Owens, 1966) supported Playford's suggestion. In many specimens from the Horton Group studied by the author, the exact margin of the inner body is difficult to discern, although its position can be inferred from a perceptible colour change, and the area underlain by the inner body has a slightly darker colour. Difficulty in seeing the exact position of the margin probably implies that the inner body is very thin. Observations made of broken specimens support this view. Thin sections were also made at 5 µm, 10 µm, and 20 µm intervals, but the results from these were not conclusive. Occasionally, a thin membrane was seen on some specimens but it was not certain if this represented an inner body or had resulted from tearing of the exine. Therefore, even though thin sectioning did not prove or disprove the presence of an inner body, it does indicate that if such a body is present, it is very thin.

Holotype. GSC 13109, Playford (1964), Horton Group (Cheverie Formation), Nova Scotia, GSC plant locality 6407.

Figured specimens. GSC 13108, 13110, and 13111, Playford (1964), Horton Group (Cheverie Formation), Nova Scotia, GSC plant locality 6407.

Emended diagnosis. Trilete camerate, amb subtriangular with rounded apices and convex to almost straight sides. Outline of intexine or inner body poorly to well defined, almost parallel to amb outline. Radius of inner body aproximately 50 to 90 per cent of overall diameter. Trilete rays more or less straight, extending almost to margin of intexine; associated folds up to 12 µm high reach equator, sinuous in outline. *Curvaturae imperfectae* generally visible. Ornament on distal surfaces consisting mainly of verrucae, with subordinate grana and coni and, less frequently, small spinae; elements usually sparsely and irregularly distributed, often evident at equatorial margin and between equator and *curvaturae imperfectae*. Verrucae relatively low, broadly rounded, sometimes bearing single, minute conus or spina. Bases of verrucae subcircular, usually discrete, or fused in groups of up to three individuals. Basal width of verrucae 1.5 to 8 µm, height 1 to 4 µm. Apart from distal sculpturing elements, exoexine finely and densely infragranulate. Irregular secondary folding common.

Diameter. 65 to 195 µm, mean 99 µm (296 specimens).

Occurrence. Cheverie Formation, Horton Group, Cheverie, Nova Scotia.

Remarks. In the Windsor Group many specimens occur that superficially resemble many of the specimens of *Spelaeotriletes pretiosus* found in the Horton Group, but which usually have certain morphological differences. These differences are gradational and are not considered sufficiently great to warrant the erection of a number of new species. However, to ignore them altogether would be misleading. Thus, a number of varieties are being formally proposed. It appears that these varieties have some stratigraphic significance.

Spelaeotriletes pretiosus (Playford) Neves and Belt emend. var. *pretiosus*

Plate 4, figure 1

1964 *Pustulatisporites pretiosus* (pars.) Playford, p. 19-20, Pl. 4, figs. 5-6, Pl. 5, fig. 1 (non. Pl. 4, fig. 7).

Discussion. This variety essentially represents the original concept of *Pustulatisporites pretiosus* Playford, 1964, but excludes specimens where the inner body is well defined and/or apical papillae are present.

Holotypes. GSC 13109, Playford (1964), Horton Group (Cheverie Formation), Nova Scotia, GSC plant locality 6407.

Figured specimen. C-078245-1, 29.9 x 99.4, GSC 73799, Cheverie Formation, Horton Group, Nova Scotia, [locality probably similar to GSC plant locality 6407 in Playford (1964)], Pl. 4, fig. 1.

Diagnosis. Trilete camerate, amb subtriangular with rounded apices and convex to almost straight sides. Outline of intexine or inner body poorly defined, almost parallel to amb outline, intexine very thin. Radius of inner body aproximately 50 to 80 per cent of overall diameter. Trilete rays virtually straight extending almost to margin of intexine; associated folds up to 12 µm high reach equator, sinuous in outline. *Curvaturae imperfectae* generally visible. Exoexine infragranulate, approximately 2 µm thick. Ornament on distal surfaces consisting mainly of verrucae, with subordinate grana and coni and, less frequently, small spinae; elements usually sparsely and irregularly distributed, often evident at equatorial margin. Verrucae relatively low, broadly rounded, sometimes bearing single minute conus or spina. Bases of verrucae subcircular, usually discrete or fused in groups of up to three individuals. Basal width of verrucae 1.5 to 8 µm, height 1 to 4 µm. Irregular secondary folding common.

Diameter. 98 to 195 µm, mean 149 µm (115 specimens).

Occurrence. Cheverie Formation, Horton Group, Cheverie, Nova Scotia. In some samples from the Cheverie Formation this species may be very abundant and dominate the assemblages.

Remarks. The intexine is too thin to be measured by conventional optical methods.

Spelaeotriletes pretiosus (Playford) Neves and Belt emend. var. *bellii* var. nov.

Plate 4, figures 2-4

1964 *Pustulatisporites pretiosus* (pars) Playford, Pl. IV, fig. 7.

Holotype. C-090406-SB-1-33-4, 53.6 x 99.1, GSC 73800, Pl. 4, fig. 2, Stewiacke Formation (probably macrofaunal Subzone A), Stewiacke borehole SB-1, Hants County.

Figured specimens. D-1370-98-3-1, 33.5 x 110.5, GSC 73801, Pl. 4, fig. 3, macrofaunal Subzone A, North Gut St. Anns, Cape Breton Island; D-1384-7-3, 29.9 x 107.4, GSC 73802, Pl. 4, fig. 4, Stewiacke Formation (probably macrofaunal Subzone A), Stewiacke borehole SB-1, Hants County.

Occurrence. Rare in the Cheverie Formation, Horton Group, Cheverie, Nova Scotia. Lower and Upper Windsor Group and lateral equivalents. For example "Stewiacke formation" (probably macrofaunal Subzone A), "MacDonald Road formation" (probably macrofaunal Subzone B), "Green Oaks formation" (probably macrofaunal Subzones C, D and E), and "Watering Brook formation" (Windsor-Canso Group boundary beds), Stewiacke borehole SB-1, Hants County. Macrofaunal Subzones B, C and D, Port Hood Island section, Cape Breton Island, Nova Scotia. NS, AT and SM zones.

Diagnosis. Trilete camerate miospore, amb subcircular to rounded subtriangular; rounded apices, sides convex. Outline of intexine sac generally well defined and subparallel to amb outline; radius of inner sac approximately 70 to 80 per cent of spore radius. Thickness of intexine approximately 1 µm. Trilete rays straight, extending almost to margin of intexine; associated narrow sinuous folds of exoexine almost reaching equator, may be up to 5 µm high; *curvaturae imperfectae* present. Apical papillae sometimes visible, generally situated 4 to 8 µm from centre, diameter 2 to 4 µm. Exoexine infragranulate, approximately 2 µm thick. Ornament occurs mainly on distal surface, but proximal surface has occasional elements; size, type and density variable on single specimen and between specimens; elements scattered irregularly, sometimes coalescing at equator. Ornament consisting mainly of small, rounded verrucae of variable shape and size, generally not higher than 2.5 µm; some verrucae have conate terminations. Occasional grana, coni, echini, pila and bacula present.

Diameter. Overall 66 to 120 µm, mean 88 µm; inner sac 46 to 96 µm, mean 57 µm (20 specimens).

Remarks. Spelaeotriletes pretiosus var. *bellii* differs from *S. pretiosus* var. *pretiosus* described by Playford (1964, Plate IV, figs. 5 and 6, and Plate V, fig. 1), in that *S. pretiosus* var. *pretiosus* is much larger with a size range of 98 to 195 µm. In *S. pretiosus* var. *pretiosus*, the inner sac is occasionally perceptible (Playford 1964, p. 20), but in *S. pretiosus* var. *bellii* it is generally well defined. Apical papillae are commonly visible on *S. pretiosus* var. *bellii* but not on *S. pretiosus* var. *pretiosus*.

Derivation of name. After the late Dr. W.A. Bell, Geological Survey of Canada, in recognition of his most significant contribution to the understanding of the geology of the Carboniferous of Eastern Canada.

Spelaeotriletes pretiosus (Playford) Neves and Belt emend. var. *windsorensis* var. nov.

Plate 4, figures 5-8

Holotype. D-1384-29-1, 42.4 x 102.7, GSC 73803, Pl. 4, fig. 5, macrofaunal Subzone D, Port Hood Island section, Cape Breton Island, Nova Scotia.

Figured specimens. GSC C-097710-1, 19.1 x 100.3, GSC 73804, Pl. 4, fig. 6, Upper Windsor(?) Group, Knoydart Point, Antigonish County; C-097704-2, 19.5 x 95.9, GSC 73805, Pl. 4, fig. 7, macrofaunal Subzone D, Cape Dauphin section, Cape Breton Island, Nova Scotia; C-097708-SEM 130, GSC 73806, Pl. 4, fig. 8, Upper Windsor (?) Group, Knoydart Point, Antigonish County.

Occurrence. Upper Windsor Group and Windsor-Canso Group boundary beds. Macrofaunal Subzones C and D, Port Hood Island, Cape Breton Island, Nova Scotia; lower, middle and upper parts of "Green Oaks formation" (probably macrofaunal Subzones C, D and E), and the "Watering Brook formation" (Windsor-Canso Group boundary beds), Stewiacke borehole SB-1, Hants County; Windsor-Canso Group boundary beds in boreholes Noranda 4 and Noranda 12, Lake Enon, Cape Breton Island, Nova Scotia; Windsor-Canso Group boundary beds near Baddeck, Cape Breton Island (D-1534-KA21), Nova Scotia. NS, AT and SM zones.

Diagnosis. Trilete camerate, amb subtriangular with rounded apices, sides convex. Outline of intexine well defined and almost parallel to amb outline, thickness approximately 1 µm; radius of inner sac approximately 90 per cent of spore radius. Trilete rays almost straight, extending almost to margin of intexine; associated folds of exoexine up to 4 µm high, almost reaching equator, sinuous in outline. *Curvaturae imperfectae* generally visible. Exoexine infragranulate, approximately 2 µm thick. Ornament on distal surface consisting of grana, small verrucae, coni and rare galeae;[1] elements generally less than 1 µm high, closely spaced and regularly distributed over surface. Occasional elements on proximal surface, especially on outer half toward equator. Apical papillae often clearly visible, outline circular, diameter approximately 5 µm, generally occurring within 10 µm radius of spore centre.

Diameter. Overall 49 to 64 µm, mean 59 µm; inner sac 40 to 57 µm, mean 51 µm (14 specimens).

Remarks. *Spelaeotriletes pretiosus* var. *windsorensis* has a mean size of 59 µm, differing from *S. pretiosus* var. *bellii*, which has a mean size of 79 µm. Also, the ornament is smaller and more closely distributed in *S. pretiosus* var. *windsorensis*, and the size of the inner sac relative to that of the overall spore body is greater in *S. pretiosus* var. *windsorensis*, than in *S. pretiosus bellii*. In spite of these general differences, there are some specimens that appear to be transitional between the two varieties, in which case the variety name may be arbitrary.

Derivation of name. The town of Windsor, Nova Scotia, from which the type section of the Windsor Group takes its name.

Spelaeotriletes tuberosus sp. nov.

Plate 4, figures 13-16

Holotype. D-1384-7-1, 41.7 x 101.8, GSC 73810, Pl. 4, fig. 13, macrofaunal Subzone B, Port Hood Island section, Cape Breton Island, Nova Scotia.

Figured specimens: D-1384-23-1, 41.8 x 104.6, GSC 73811, Pl. 4, fig. 14, C-097704-2, 18.3 x 103.4, GSC 73812, Pl. 4, fig. 15, macrofaunal Subzone D, Port Hood Island section, Cape Breton Island, Nova Scotia; C-097708-SEM 138, GSC 73813, Pl. 4, fig. 16, Upper (?) Windsor Group, Knoydart Point, Antigonish County, Nova Scotia.

Occurrence. Lower and Upper Windsor Group and Windsor-Canso Group boundary beds. Macrofaunal Subzones B, C and D of Port Hood Island section, Cape Breton Island, and macrofaunal Subzone D, Cape Dauphin section, Cape Breton Island, Nova Scotia. Lowermost and uppermost parts of "Green Oaks formation" (probably macrofaunal Subzones C and E), Stewiacke borehole SB-1, Hants County, Nova Scotia; Windsor-Canso Group boundary beds of borehole Noranda 4, Lake Enon, Cape Breton Island, Nova Scotia. NS and AT zones.

Diagnosis. Trilete camerate miospores, amb rounded subtriangular, apices subrounded, sides convex. Outline of intexine sac generally discernible, but sometimes faint, subparallel to amb outline, radius of inner sac approximately 60 to 75 per cent of spore radius; intexine approximately 0.1 µm thick. Trilete rays straight, extending almost to margin of intexine; associated narrow sinuous folds up to 3.5 µm high, *curvaturae imperfectae* present. Exoexine infragranulose, approximately 1 µm thick. Ornament mainly on distal surface consisting of scattered verrucae and rugulae, irregular in size and shape, but generally more densely distributed in centre of spore than at equator; also, elements larger (up to 3 µm) near centre and smaller (approximately 1 µm) at equator.

Diameter. Overall 55 to 108 µm, mean 65 µm; inner sac 36 to 69 µm, mean 47 µm (13 specimens).

Remarks. *Spelaeotriletes tuberosus* differs from *S. pretiosus* var. *pretiosus* comb. nov. by having a clearly discernible inner sac, and being smaller than *S. pretiosus* var. *pretiosus* comb. nov., which has a mean size of 149 µm (Playford, 1964). *Spelaeotriletes tuberosus* differs from *S. pretiosus* var. *bellii* by having a less variable and less dense ornament. In addition, apical papillae may occur on *S. pretiosus* var. *bellii* but have not been seen on *S. tuberosus*. *Spelaeotriletes pretiosus* var. *windsorensis* differs from *S. tuberosus* by having an ornament of grana, small verrucae, coni and rare galeae, and often possessing apical papillae.

Derivation of name. Latin adjective, *tuberosus*, full of swellings or protuberances.

Subturma MEMBRANATITRILETES Neves and Owens, 1966

Infraturma CONTINUATI Neves and Owens, 1966

Genus *Discernisporites* Neves 1958, emend.
Neves and Owens, 1966

Type species. *Discernisporites irregularis* Neves, 1958.

Discernisporites barssii sp. nov.

Plate 4, figures 17-19

Holotype. D-1384-14-1, 46.0 x 98.3, GSC 73814, Pl. 4, fig. 17, macrofaunal Subzone C, Port Hood Island section, Cape Breton Island, Nova Scotia.

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[1] Galeae is a term proposed by Sullivan (1964) for a similar ornament of sharply tapered spines on a broad bulbous base, occurring on *Vallatisporites ciliaris* Sullivan, 1964.

Figured specimens. D-1014-3S-1-72-6-7, 33.0 x 102.3, GSC 73815, Pl. 4, fig. 18, macrofaunal Subzone D, Cape Dauphin, Cape Breton Island, Nova Scotia; D-1384-7-3, 17.4 x 102.3, GSC 73816, Pl. 4, fig. 19, macrofaunal Subzone B, Port Hood Island section, Cape Breton Island, Nova Scotia.

Occurrence. Macrofaunal Subzones B, C and D, Port Hood Island section, macrofaunal Subzone D, Cape Dauphin, Cape Breton Island, Nova Scotia. NS and AT zones.

Diagnosis. Trilete camerate spores. Amb rounded triangular to circular. Inner body margin generally subparallel to equator. Distance between equator and inner body margin approximately one quarter to one third of spore radius. Laesurae well developed, simple and straight, extending almost to margin of inner body. Exoexine and intexine laevigate. Inner body relatively thick (approximately 1 µm), exoexine thin (approximately 0.1 µm), generally very pale in colour in comparison. In proximal/distal compressions inner body margin subparallel to equator.

Dimensions. 30 to 61 µm, mean 45 µm (12 specimens).

Remarks. This species superficially resembles *Auroraspora macra* Sullivan, 1958, but in *A. macra* the intexine is laevigate to scabrate, and the exoexine has a spongy infrastructure. Also, from photographs of *A. macra* (Sullivan, 1958, Pl. 27, figs. 6-10), there does not appear to be such a large relative difference in the thickness of the exoexine and intexine as there is in *Discernisporites barssii.* Also in proximal/distal compressions of *D. barssii,* the inner body is centrally placed and its margin is subparallel to the equator; this is not generally the case with *A. macra,* possibly suggesting a different type of attachment of the inner body to the outer body (exoexine). *Endosporites minutus* Hoffmeister, Staplin and Malloy, 1955 differs by having a faintly granulose central body, and weak laesurae that extend approximately two thirds of the central body radius. Also, in *E. minutus,* in proximal/distal compressions, the central body may be eccentrically placed and not centrally, as with *D. barssii.*

Derivation of name. After M.S. Barss, Geological Survey of Canada, in recognition of his contribution to Carboniferous palynology in Canada.

Discernisporites diaphanes sp. nov.

Plate 5, figures 1-3

Holotype. D-1384-16-1, 45.0 x 105.8, GSC 73817, Pl. 5, fig. 1, macrofaunal Subzone C, Port Hood Island section, Cape Breton Island, Nova Scotia.

Figured specimens. D-1384-16-1, 34.5 x 94.3, GSC 73818, Pl. 5, fig. 2, (same sample as holotype); C-090406-SB-1-21-5, 35.0 x 99.6, GSC 73819, Pl. 5, fig. 3, "Stewiacke formation" (probably macrofaunal Subzone A), Stewiacke borehole, Hants County, Nova Scotia.

Occurrence. Lower and Upper Windsor Group, Windsor-Canso Group boundary beds. "Stewiacke formation" (probably macrofaunal Subzone A), Stewiacke borehole SB-1, Hants County, Nova Scotia; macrofaunal Subzones B, C and D, Port Hood Island section, Cape Breton Island. Windsor-Canso Group boundary beds near Baddeck, GSC locality D-1534, KA 63-C. NS and AT zones.

Diagnosis. Trilete camerate, shape triangular. In unfolded specimens, sides convex to almost straight, outline of intexine subparallel. Exoexine punctate, relatively thin (approximately 0.1 µm), often showing secondary folding toward distal surface in interapical regions in area between inner body and equator. Intexine relatively thick (approximately 1.5 µm), subtriangular, sides slightly convex to almost straight. Trilete rays straight extending almost to margin of intexine, generally accompanied by folds extending almost to equator. Secondary folding of specimens very common: two interapical sides of exoexine often folded toward one another on distal surface. Radius of inner sac approximately 75 per cent that of spore radius.

Diameter. 53 to 80 µm, mean 66 µm; inner body 40 to 65 µm, mean 51 µm (14 specimens).

Remarks. Discernisporites diaphanes differs from *Discernisporites micromanifestus* by its triangular shape and its distinctive, relatively thin exoexine.

Derivation of name. Greek, *diaphanes,* diaphanous.

Discernisporites macromanifestus (Hacquebard) comb. nov.

Plate 5, figure 4

1957 *Endosporites macromanifestus* Hacquebard, p. 317, Pl. 3, figs. 14, 15.

1960 *Auroraspora macromanifestus* (Hacquebard) Richardson, p. 50, Pl. 14, figs. 1 and 2, Textfig. 6A.

Figured specimen. Stewiacke borehole C-090406-SB-1-8-3, 45.4 x 104.5, GSC 62480, Pl. 5, fig. 4.

Occurrence. Lower Windsor Group. Macrofaunal Subzone A. Gays River Formation and "Carrolls Corner formation", Stewiacke borehole SB-1, Hants County, Nova Scotia. It is not certain whether the few specimens of this species were found *in situ* or had been reworked from the Horton Group. NS Zone.

Remarks. Richardson (1960) emended the genus *Auroraspora* and considered that because neither *Endosporites macromanifestus* Hacquebard, 1957 nor *Endosporites micromanifestus* Hacquebard, 1957 possessed a limbus, they should be transferred to *Auroraspora.* Neves and Owens (1966) emended the genus *Discernisporites* Neves, 1958 and suggested that the emended genus provided a more suitable generic assignment for *Endosporites macromanifestus* Hacquebard and *E. micromanifestus* Hacquebard. They considered *Discernisporites concentricus* Neves, 1958 to be a junior synonym of *E. micromanifestus* and the formal combination of *Discernisporites micromanifestus* was made by Sabry and Neves (1971). Although the species *Endosporites macromanifestus* is larger, it is closely related to *Discernisporites micromanifestus.* Therefore, *Endosporites macromanifestus* is transferred to the genus *Discernisporites* here.

Discernisporites micromanifestus (Hacquebard) Sabry and Neves, 1971

Plate 5, figures 5, 6

Figured specimens. C-090406-SB-1-99-6, 43.8 x 106.0, GSC 62489, Pl. 5, fig. 6, Windsor-Canso Group boundary beds;

D-1384-16-1, 37.6 x 105.7, GSC 73820, Pl. 5, fig. 6, macrofaunal Subzone C, Port Hood Island section, Cape Breton, Nova Scotia.

Occurrence. Lower and Upper Windsor Group (macrofaunal Subzones A, B, C, D and E), Windsor-Canso Group boundary beds, and lateral equivalents. NS, AT and SM zones.

Remarks. In the Windsor material specimens, the size of the inner body relative to the overall diameter is variable, and there are specimens similar to those illustrated by Hacquebard (1957, Pl. 3, fig. 16), where the inner body is relatively small, and Sabry and Neves (1971, Pl. 3, fig. 11), where the inner body is relatively large. Also present are specimens intermediate between these two illustrated examples.

Suprasubturma PSEUDOSACCITRILETES Richardson, 1965

Infraturma MONOPSEUDOSACCITI Smith and Butterworth, 1967

Genus *Schulzospora* Kosanke, 1950

Type species. *Schulzospora rara* Kosanke, 1950.

Schulzospora bilunata sp. nov.

Plate 5, figures 15-17

1970 *Schulzospora* cf. *S. elongata* Neves and Belt, Pl. 2, fig. 6.

1980 *Schulzospora* cf. *S. elongata* Utting, Pl. 2, fig. 10.

Holotype. C-090406-SB-1-99-5, 40.8 x 104.3, GSC 62504, Pl. 5, fig. 15, "Watering Brook formation" (Windsor-Canso Group boundary beds), Stewiacke borehole SB-1, Hants County, Nova Scotia.

Figured specimens. C-090406-SB-1-99-6, 49.6 x 100.6, GSC 73828, Pl. 5, fig. 16, and C-090406-SB-1-99-2, 45.5 x 103.6, GSC 73829, Pl. 5, fig. 17, "Watering Brook formation" (Windsor-Canso Group boundary beds), Stewiacke borehole SB-1, Hants County, Nova Scotia.

Occurrence. Windsor-Canso Group boundary beds. "Watering Brook formation" (Windsor-Canso Group boundary beds), Stewiacke borehole SB-1, Hants County, Nova Scotia; Windsor-Canso Group boundary beds of borehole Noranda 4, Lake Enon, Cape Breton Island, Nova Scotia; Windsor-Canso Group boundary beds near Baddeck, Cape Breton Island, Nova Scotia. SM Zone.

Diagnosis. Trilete spore with bilateral appearance due to presence of elliptical pseudosaccus. Trilete rays not always visible, laesurae straight, approximately two thirds of radius of inner body. Exine punctate. Body slightly elliptical with long diameter less than that of pseudosaccus; short diameter of spore body only slightly less than that of bladder, which thus forms two crescent shaped extensions. Intexine thin (less than 0.25 μm), exoexine approximately 0.25 μm.

Diameter. Overall length 52 to 73 μm, mean 61 μm, width 30 to 50 μm, mean 39 μm; central body length 22 to 45 μm, mean 34 μm, width 24 to 38 μm, mean 32 μm (13 specimens measured).

Remarks. Schulzospora bilunata is wider than *S. elongata* Hoffmeister, Staplin and Malloy, 1955, although the length is approximately the same. The outline of *S. bilunata* is similar to that of *S. campyloptera* (Waltz) Hoffmeister, Staplin and Malloy, 1955, but *S. bilunata* is larger (length 90 to 114 μm, width 65 to 75 μm) and the spore body is less elliptical along the length. Thus *S. bilunata* may occupy an intermediate position between *S. elongata* and *S. campyloptera. Schulzospora rara* Kosanke, 1950 differs from *S. bilunata* in being larger and having a spherical spore body. *Schulzospora rara* forma *minima* Dybová-Jachowiczowa, 1966 is similar in size, but has a less elongate spore body than *S. bilunata. Schulzospora primigenia* Dybová and Jachowicz, 1957 is similar to *S. bilunata*, but is generally larger and has a circular spore body. *Schulzospora primigenia* Dybová and Jachowicz, 1957 forma *elongata* Dybová and Jachowicz, 1957 is also larger than *S. bilunata* and is more elongate.

Derivation of name. Latin, *bi*, two; Latin, *lunatus*, adjective, crescent shaped.

Infraturma TRILETISACCITI Leschik, 1955

Genus *Auroraspora* Hoffmeister, Staplin and Malloy, 1955

Type species. *Auroraspora solisortus* Hoffmeister, Staplin, and Malloy, 1955.

Auroraspora macra Sullivan, 1968

Plate 5, figure 12

Figured specimen. D-1384-10-1, 43.3 x 102.0, GSC 83360, Pl. 5, fig. 14, macrofaunal Subzone B, Port Hood Island section, Cape Breton Island, Nova Scotia. NS, AT, and SM zones.

Remarks. Some specimens closely resemble those described by Sullivan (1968). Other specimens (e.g., Pl. 5, fig. 14) resemble *Colatisporites decorus* (Bharadwaj and Venkatachala) Williams, 1973, in which the diameter of the exoexine is only slightly greater than that of the intexine. There appears to be continuous variation between *C. decorus* and *A. macra* and, in this paper, the assignation of intermediate specimens to one species rather than the other is arbitrary. Van der Zwan (1980) discussed in detail the problems concerning variation within the *A. macra* morphon and suggested the recognition of a series of variants that may be part of a continuous morphological variation.

Turma PLICATES (PLICATA Naumova, 1937, 1939) Potonié, 1960

Subturma PRAECOLPATES Potonié and Kremp, 1954

Genus *Schopfipollenites* Potonié and Kremp, 1954

Type species. *Schopfipollenites ellipsoides* (Ibrahim) Potonié and Kremp, 1954.

Schopfipollenites acadiensis sp. nov.

Plate 5, figures 7-11

1980 *Schopfipollenites* cf. *S. ellipsoides* Utting, Pl. 2, figs. 6, 7.

Holotype. D-1384-23-1, 44.4 x 101.3, GSC 73821, Pl. 5, fig. 7, macrofaunal Subzone D, Port Hood Island section, Cape Breton Island, Nova Scotia.

Figured specimens. D-1384-23-1, 29.5 x 95.7, GSC 73822, Pl. 5, fig. 8; D-1384-28-1, 44.6 x 96.3, GSC 73823, Pl. 5, fig. 9, and D-1384-21-1, 30.7 x 98.7, GSC 73824, Pl. 5, fig. 10, from macrofaunal Subzone D, Port Hood Island section, Cape Breton Island, Nova Scotia; C-097708-SEM 132, GSC 73825, Upper (?) Windsor Group, Knoydart Point, Antigonish County, Nova Scotia. AT and SM zones.

Occurrence. Upper Windsor Group and Windsor-Canso Group boundary beds. Macrofaunal Subzones C and D of Port Hood Island section, Cape Breton Island, Nova Scotia; lowermost and uppermost parts of the "Green Oaks formation" (probably macrofaunal Subzones C and D), Stewiacke borehole SB-1, Hants County; macrofaunal Subzones D and E of Cape Dauphin section, Cape Breton Island; Windsor-Canso Group boundary beds from boreholes Noranda 4 and Noranda 12, Lake Enon, Cape Breton; Watering Brook Formation (Windsor-Canso Group boundary beds), Stewiacke borehole SB-1, Hants County; Windsor-Canso Group boundary beds, Baddeck, Cape Breton Island.

Diagnosis. Shape oval to almost circular. Proximal suture or umbo slightly bent near middle, running almost parallel to long axis, approximately three quarters of length. Distal folds with variable development, generally longitudinally aligned. Specimens often folded almost parallel to long axis. Margin smooth, exoexine infragranulate, approximately 3 μm thick. Intexine approximately 2 μm thick. Inner spore membrane in some specimens showing no withdrawal from exoexine, its outline running almost parallel to outline of spore. Some specimens with partial withdrawal of inner spore membrane, others with more or less complete withdrawal (Pl. 5, fig. 10).

Diameter. Long axis 78 to 125 μm, mean 102 μm; short axis 55 to 75 μm, mean 65.5 μm (15 specimens). Inner spore membrane dimensions vary from being approximately 95 per cent of the diameter of the spore, where there is no apparent withdrawal of the intexine, to approximately 70 per cent, where withdrawal is most developed.

Remarks. Schopfipollenites acadiensis is similar to *S. ellipsoides*, although much smaller, the long axis ranging from 78 to 125 μm, whereas in *S. ellipsoides* (Potonié and Kremp, 1956), it is 200 to 500 μm. Also the umbonal development in *S. acadiensis* is relatively poor compared with that of *S. ellipsoides*. Because of the significant size difference, a new species has been proposed. In some specimens of *S. acadiensis*, where an inner spore membrane is well developed, the specimens resemble those of *S. ellipsoides* var. *corporeus* Neves, 1961, but are smaller than them. However, in the case of *S. acadiensis*, the development of an inner spore membrane is variable and in some specimens it may be only partially developed. Also both forms, with or without the well developed inner spore membranes, may occur in association with one another in the same sample.

Derivation of name. From Acadia, an area within Nova Scotia, New Brunswick and Maine, which was a cause of friction between England and France from 1613 to 1713.

Group ACRITARCHA Evitt, 1963

Genus *Actinotodissus*
Loeblich and Tappan, 1978

Type species. *Actinotodissus longitaleosus* Loeblich and Tappan, 1978.

Actinotodissus sp. A

Plate 5, figure 21

Figured specimen. D-1384-33-1, 29.5 x 105.4, GSC 73833, Pl. 5, fig. 21, Upper Windsor Group, macrofaunal Subzone D, Port Hood Island section, Cape Breton, Nova Scotia.

Occurrence. One specimen from Upper Windsor Group, macrofaunal Subzone D, Port Hood Island section, Cape Breton, Nova Scotia. AT Zone.

Description. Polygonal outline, with slight elongation, consisting of one layer, smooth, approximately 0.1 μm thick. Simple, flagellate, uniformly tapering processes, 26 in number, open to body cavity. Middle of body, normal to long axis, has smooth band approximately 7 μm wide lacking processes; equal number of processes (13) on each side of band.

Dimensions. Body 27 μm (short axis), 33 μm (long axis); processes approximately 18 μm long, basal diameter 5 to 9.5 μm (one complete specimen only).

Remarks. Species of *Actinotodissus* are known from middle and upper Ordovician strata (Loeblich and Tappan, 1978) and it seems possible that the specimen found has been reworked, although the Thermal Alteration Index and the nature of preservation is comparable to that of the spores *in situ*.

Genus *Eisenackidium* Cramer and Díez, 1968
emended Eisenack, Cramer and Díez, 1973

Type species. *Eisenackidium triplodermum* Cramer, 1967

Eisenackidium playfordii sp. nov.

Plate 6, figures 1-4

Holotype. D-1384-29-1, 41.4 x 102.0, GSC 73835, Pl. 6, figs. 1, 4, Upper Windsor Group, macrofaunal Subzone D, Port Hood Island section, Cape Breton Island, Nova Scotia.

Figured specimens. D-1384-7-2, 38.2 x 99.4, GSC 73835, Pl. 6, fig. 2, and D-1384-7-2, 38.0 x 100.5, GSC 73836, Pl. 6, fig. 3, Lower Windsor Group, macrofaunal Subzone B, Port Hood Island section, Cape Breton Island, Nova Scotia.

Occurrence. Macrofaunal Subzone B (Lower Windsor) and macrofaunal Subzone D (Upper Windsor), Port Hood Island section, Cape Breton Island, Nova Scotia. NS and AT zones.

Diagnosis. Double-walled acritarch, consisting of a hollow, relatively thick (approximately 0.25 μm), single-walled body surrounded by a thin (approximately 0.1 μm), loosely attached, finely granulose outer wall, which extends into four tapered processes. Fine grana (less than 0.5 μm diameter) apparently of variable density, in some places closely spaced, in others sparse (Pl. 6, fig. 4). Inner body rounded tetrahedral in shape. Numerous secondary folds both on inner and outer walls of specimen; on processes, folds run parallel to subparallel to long axis. A similar feature was noted by Eisenack et al. (1973) in their emended description of *Eisenackidium.*

Dimensions. Inner body 27-34 µm (short axis), 39.0-53 µm (long axis); processes 28-39 µm long, 12 to 24 µm at the base (4 specimens).

Remarks. All of the species of *Eisenackidium* listed by Eisenack et al. (1973) occur in the Devonian. The genus *Crameria* Lister, 1970 was considered by Eisenack et al. (*ibid.*) to be a junior synonym of *Eisenackidium. Crameria* cf. *C. duplex* (Cramer) Lister, 1970 was recorded in the Ludlow series (Silurian) of Shropshire, England. There is no record known to the author of *Eisenackidium* occurring in the Carboniferous, although the thermal alteration and nature of preservation is similar to that of the spores *in situ.*

Derivation of name. After G. Playford, in recognition of his contribution to the palynology of the Lower Carboniferous of Canada.

Genus *Elektoriskos* Loeblich, 1970

Type species. *Elektoriskos aurora* Loeblich, 1970.

Elektoriskos sp. A

Plate 6, figure 6

Figured specimen. C-090423-2, 13.0 x 107.0, GSC 73838, Pl. 6, fig. 6, Mollichignick Member, Robins River Formation, Codroy Group.

Occurrence. Two specimens from two samples from the Mollichignick Member (C-090423 and C-090422), Robinsons River Formation, Codroy Group. The stratigraphic position of the Mollichignick Member at this locality is not certain; spore assemblages that may be correlated with those from the Lower Windsor Group occur in the lower beds, but those from the upper beds contain a similar assemblage to those of the Upper Windsor Group. The two acritarch specimens were found in the lower beds (see Appendix 3, southwestern Newfoundland section C, a). NS Zone.

Description. Outline of central body subcircular. Thin wall (approximately 0.25 µm), psilate, with numerous long slightly tapered, thin, flexible, simple, unbranched processes, which appear to be solid. Basal diameter of processes approximately 0.5 µm, distance between bases 1-2 µm, length up to 12.75 µm, extremities very thin. Central body with simple slit 4 µm long (seen on one specimen).

Dimensions. Central body diameter 22.5 µm (2 specimens).

Genus *Leiosphaeridia* Eisenack, 1958

Type species. *Leiosphaeridia baltica* Eisenack, 1958.

Leiosphaeridia? *scotia* sp. nov.

Plate 6, figures 7-11

Holotype. C-097708-3, 30.5 x 96.3, GSC 73839, Pl. 6, fig. 7; Upper Windsor Group, Knoydart Point, Antigonish County, Nova Scotia.

Figured specimens. C-097708-3, 45.6 x 103.2, GSC 73840, Pl. 6, fig. 8; C-097708-2, 24.4 x 110.0, GSC 73841, Pl. 6, fig. 9; C-097708-SEM 140 and 141, GSC 73842, Pl. 6, figs. 10, 11, Upper(?) Windsor Group, Knoydart Point, Antigonish County, Nova Scotia.

Occurrence. Lower Windsor Group, macrofaunal Subzone B, Port Hood Island section, Cape Breton Island, Nova Scotia; Upper(?) Windsor Group, Knoydart Point, Antigonish County, Nova Scotia. NS and AT zones.

Diagnosis. Subcircular to oval body, shape modified by secondary folds generally running subparallel to long axis, up to 10 µm high. Microfolds less than 0.5 µm high (Pl. 6, fig. 11) generally running approximately perpendicular to long axis; either present over whole body, or only in one area, position of which may vary from one specimen to another. Microfolds sometimes almost parallel to longer folds, which run parallel to long axis. Ornament occurring evenly over surface of specimens, consisting of micrograna less than 0.5 µm high. Thickness of body wall approximately 0.5 µm, but may also be slightly variable, as darker patches seen on certain specimens.

Diameter. Long axis 66 to 147 µm, mean 100 µm; short axis 46 to 100 µm, mean 73 µm (21 specimens).

Remarks. This species has only tentatively been placed in *Leiosphaeridia* because it does not appear to possess a pylome, nor is it completely smooth, possessing micrograna.

Derivation of name. From Nova Scotia, the province where the specimens were found.

Leiosphaeridia? sp. A

Plate 6, figure 12

Figured specimen. D-1384-11-2, 34.4 x 109.3; GSC 73843, Pl. 6, fig. 12.

Occurrence. Lower Windsor Group, Lake Enon area, Borehole K112, 204.3 m and 232.17 m, Cape Breton, Lower Windsor Group, macrofaunal Subzone B, Port Hood Island section, Cape Breton Island, Nova Scotia. NS Zone.

Description. Approximately circular to oval with no haptotypic marks observed. Secondary folds running subparallel to equatorial margins common. Preservation poor due to growth of pyrite crystals on surface, but, where there is no damage, surface appears laevigate. Wall approximately 1 µm thick. Some specimens with very thin perine covering them, visible where it overlaps equator, e.g. Pl. 6, fig. 12.

Dimensions. 134 µm to 357 µm, mean 248 µm (15 specimens).

Remarks. The specimens are tentatively included in the genus *Leiosphaeridia*, although no pylome was seen. The mean size of these specimens is much greater than that of *Leiosphaeridia*? *scotia.*

Incertae sedis

Genus *Biannulatisphaerites* Neville, 1973

Type species. *Biannulatisphaerites simplex* Neville, 1973.

Biannulatisphaerites simplex Neville, 1973

Plate 5, figures 18-19

Figured specimens. C-097708-5-3, 42.8 x 98.0, GSC 73831, Pl. 5, fig. 18, and C-097708-5-3, 25.1 x 99.7, GSC 73832, Pl. 5, fig. 19, undifferentiated Upper Windsor Group, Knoydart Point, Antigonish County, Nova Scotia.

Occurrence. Rare in Lower and Upper Windsor Group and Windsor-Canso Group boundary beds. NS, AT and SM zones.

Description. The Atlantic Canada specimens are similar to those described by Neville (in Neves et al., 1973), but differ in being generally larger. The size range given by Neville was 21 to 32 µm (mean 28 µm), but the specimens described here are 36.75 to 49.0 µm (mean 43.5 µm; 7 specimens).

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APPENDIX 1

This appendix contains curation numbers and field or borehole numbers referred to in the text and Appendix 3; names of sample collectors are also given.

Key to curation numbers

C-097701	*Institute of Sedimentary and Petroleum Geology, Calgary, Alberta*
D-1325	*Atlantic Geoscience Centre, Dartmouth, Nova Scotia*
GSC-1659	*Geological Survey of Canada, Ottawa, Ontario*
ROM-Bos-1-1	*Royal Ontario Museum, Toronto, Ontario*
SB-1-(1-120)	*Borehole number with number of samples in brackets*

Locality	Stratigraphic unit	Curation no.	Field or borehole no.[1]	Collector
NOVA SCOTIA				
A. Cape Breton Island				
(a) Port Hood Island	Lower and Upper Windsor	D-1384	UF26-7-76-1 to UF25-7-76-34	P.S. Giles and J. Utting, 1976
	Upper Windsor	ROM-PHI-C1-1		P.H. von Bitter, 1976
	Upper Windsor	ROM-PHI-C1-2		P.H. von Bitter, 1976
	Upper Windsor	POM-PHI-C1-3		P.H. von Bitter, 1976
	Upper Windsor	ROM-PHI-C1-4		P.H. von Bitter, 1976
	Upper Windsor	ROM-PHI-C1-5		P.H. von Bitter, 1976
	Upper Windsor	ROM-PHI-C1-6		P.H. von Bitter, 1976
	Upper Windsor	ROM-PHI-C1-7		P.H. von Bitter, 1976
	Upper Windsor	ROM-PHI-C1-8		P.H. von Bitter, 1976
	Upper Windsor	ROM-PHI-C2-1		P.H. von Bitter, 1976
	Upper Windsor	ROM-PHI-C2-2		P.H. von Bitter, 1976
	Upper Windsor	ROM-PHI-E1-1		P.H. von Bitter, 1976
	Upper Windsor	ROM-PHI-E1-3		P.H. von Bitter, 1976
(b) Lake Enon Area	Lower Windsor	C-097701	K112(3)[1]	R.C. Boehner, 1982
	Lower Windsor	C-097702	K116(1)[1]	R.C. Boehner, 1982
	Upper Windsor	C-097703	K117(3)[1]	R.C. Boehner, 1982
	Windsor-Canso boundary	D-1325	Noranda 4(3)[1]	H.H.J. Geldsetzer and J. Utting, 1976
	Windsor-Canso boundary	D-1332	Noranda 12(3)[1]	H.H.J. Geldsetzer and J. Utting, 1976
(c) Cape Dauphin	Lower Windsor	D-1014	JSI-72, 0-30	H.S.M.Z. Sabry 1972
	Lower Windsor	C-090404	UF21-7-76-6	J. Utting, 1976
	Upper Windsor	D-1014	JSI-72-6	H.S.M.Z. Sabry, 1972
	Upper Windsor	C-090402	UF21-7-76-10	J. Utting, 1976
	Upper Windsor	D-1014	JSI-72-8	H.S.M.Z. Sabry, 1972
	Windsor-Canso boundary	C-097712	UF23-7-76-14	J. Utting, 1976
(d) Frenchvale Brook	Lower Windsor	GSC-plant locality 1659	280	W.A. Bell and D.J. McNeil, 1930
(e) St. Ann's Bay	Lower Windsor	D-1370	76GCA-98-3	H.H.J. Geldsetzer, 1976
(f) North Shore Provincial Park	Lower Windsor	D-1373	76GSC-106-6	H.H.J. Geldsetzer, 1976
(g) Baddeck	Windsor-Canso boundary	D-1534	KA21	D.G. Kelley, 1963
	Windsor-Canso boundary	D-1534	KA63-C	D.G. Kelley, 1963
	Windsor-Canso boundary	D-1534	KA63-D	D.G. Kelley, 1963
(h) Broad Cove	Windsor-Canso boundary	C-090418	UF11-9-79-2	P.S. Giles and J. Utting, 1979
	Windsor-Canso boundary	C-090419	UF11-9-79-3	P.S. Giles and J. Utting, 1976
(i) Lake Ainslie	Lower Windsor	D-1380	76GCA-116-3	H.H.J. Geldsetzer, 1976

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[1] Indicates borehole name and/or number; total number of core samples shown in brackets; total number of samples of cuttings, prefixed with letters 'ct', shown in brackets.

Locality	Stratigraphic unit	Curation no.	Field or borehole no.[1]	Collector
B. Mainland Nova Scotia				
(a) Shubenacadie Basin	Windsor and Windsor-Canso boundary	C-090406	SB-1(120)	R.C. Boehner, P.S. Giles and J. Utting, 1976
(b) Kennetcook River	Upper Windsor Windsor-Canso boundary	C-090407 to C-090417	UF28-7-77-142 to UF28-7-77-152	J. Utting, 1977
	Windsor-Canso boundary	C-097704	UF23-7-76-1	J. Utting, 1977
(c) Knoydart Point	Upper Windsor	D-1010(A)	JS32-72-4	H.M.S.Z. Sabry, 1972
	Upper Windsor	D-1010(B)	JS32-72-5	H.M.S.Z. Sabry, 1972
	Upper Windsor	C-097708	UF23-7-76-5	J. Utting, 1976
	Upper Windsor	C-097709	UF23-7-76-6	J. Utting, 1976
	Upper Windsor	C-097710	UF23-7-76-7	J. Utting, 1976
(d) Cheverie	Cheverie Fm.	C-078245	21H-9P	J.D. Keppie and J. Utting, 1981
C. Offshore Nova Scotia				
(a) Cabot Strait	Windsor Group	Nil	2195-2725 m Petro-Canada et al., St. Paul, P-91 (ct3)[1]	Petro-Canada, 1983
QUÉBEC				
Magdalen Island				
(a) Havre aux Maisons Island	Lower Windsor	D-1481	77GSCA66-1	H.H.J. Geldsetzer, 1977
	Lower Windsor	C-097719	UF10-7-77-18	J. Utting, 1977
	Lower Windsor	C-097720	UF10-7-77-19	J. Utting, 1977
	Lower Windsor	C-097721	UF10-7-77-20	J. Utting, 1977
	Lower Windsor	C-090436	UF9-7-771	J. Utting, 1977
	Lower Windsor	C-090437	UF9-7-77-2	J. Utting, 1977
	Lower Windsor	C-090438	UF9-7-77-3	J. Utting, 1977
	Lower Windsor	C-090439	UF9-7-77-4	J. Utting, 1977
	Lower Windsor	C-090440	UF9-7-77-5	J. Utting, 1977
	Lower Windsor	C-090441	UF9-7-77-6	J. Utting, 1977
(b) Havre Aubert	Lower Windsor	D-1477	77GCA58-5	H.H.J. Geldsetzer, 1977
(c) Île Boudreau	Upper Windsor	C-090441	UF11-7-77-25	J. Utting, 1979
	Upper Windsor	ROM-IDM-3-2		H. Plint-Geberl, 1979
	Upper Windsor	ROM-IDM-3-3		H. Plint-Geberl, 1979
	Windsor-Canso boundary	D-1483	77GCA56-15	H.H.J. Geldsetzer, 1977
NEW BRUNSWICK				
(a) Hopewell Cape Area	Lower Windsor	D-1471	77GCA44-6	H.H.J. Geldsetzer, 1977
	Lower Windsor	D-1471	77GCA44-4	H.H.J. Geldsetzer, 1977
	Lower Windsor	D-1971		S.R. McCutcheon, 1981
	Lower Windsor	C-090434	UF6-7-77-2	J. Utting, 1977
(b) Kings County	Lower Windsor	C-090401	Millstream No. 1 (7)[1]	J. Utting, 1977

Locality	Stratigraphic unit	Curation no.	Field or borehole no.[1]	Collector
S.W. NEWFOUNDLAND				
Ship Cove Formation				
(a) Codroy Island	Lower Windsor	C-097738	UF20-7-77-118	J. Utting, 1977
(b) Fischells Brook	Lower Windsor	ROM Shp-Cv-4-1		P.H. von Bitter and H.A. Plint-Geberl, 1981
	Lower Windsor	ROM Shp-Cv-Sp-1		P.H. von Bitter and H.A. Plint-Geberl, 1981
	Lower Windsor	ROM Shp-Cv-Sp-2		P.H. von Bitter and H.P. Plint-Geberl, 1981
	Lower Windsor	ROM Shp-Cv-4-2		P.H. von Bitter and H.P. Plint-Geberl, 1981
	Lower Windsor	ROM Shp-Cv-4-3		P.H. von Bitter and H.A. Plint-Geberl, 1981
(c) Aguathuna	Lower Windsor	ROM-Agu-1-1		P.H. von Bitter and H.A Plint-Geberl, 1981
	Lower Windsor	ROM-Agu-1-2		P.H. von Bitter and H.A. Plint-Geberl, 1981
(d) Boswarlos	Lower Windsor	ROM-Agu-1-5		P.H. von Bitter and H.A. Plint-Geberl, 1981
	Lower Windsor	ROM-Bos-1-3		P.H. von Bitter and H.A. Plint-Geberl, 1981
	Lower Windsor	ROM-Bos-1-2		P.H. von Bitter and H.A. Plint-Geberl, 1981
	Lower Windsor	ROM-Bos-1-1		P.H. von Bitter and H.A. Plint-Geberl, 1981
(e) Romaines Brook	Lower Windsor	ROM-Rom-1-2		P.H. von Bitter and H.A. Plint-Geberl, 1981
	Lower Windsor	ROM-Rom-1-3		P.H. von Bitter and H.A. Plint-Geberl, 1981
Codroy Road Formation				
(a) between Codroy and Woodville	Lower Windsor	C-097731	UF20-7-77-119	J. Utting, 1977
	Lower Windsor	C-097732	UF20-7-77-120	J. Utting, 1977
	Lower Windsor	C-097733	UF20-7-77-121	J. Utting, 1977
	Lower Windsor	C-097734	UF20-7-77-122	J. Utting, 1977
(b) 1 km south of Woodville	Lower Windsor	C-097735	UF20-7-77-123	J. Utting, 1977
	Lower Windsor	C-097736	UF20-7-77-124	J. Utting, 1977
	Lower Windsor	C-097737	UF20-7-77-125	J. Utting, 1977
Robinsons River Formation				
Mollichignick Member				
(a) Grand Codroy River	Upper Windsor	C-090420	UF21-7-77-139	J. Utting, 1977
	Lower? Windsor	C-090421	UF21-7-77-138	J. Utting, 1977
	Lower? Windsor	C-090422	UF21-7-77-137	J. Utting, 1977
	Lower? Windsor	C-090423	UF21-7-77-136	J. Utting, 1977
	Lower? Windsor	C-090424	UF21-7-77-135	J. Utting, 1977
	Lower? Windsor	C-090425	UF21-7-77-134	J. Utting, 1977

Locality	Stratigraphic unit	Curation no.	Field or borehole no.[1]	Collector
Undifferentiated Lower Codroy Group				
(a) Heatherton	Upper Windsor	ROM-Heath-2-9		P.H. von Bitter and H.A. Plint-Geberl
Woody Cape Formation				
(a) North of Wood Cape	Upper Windsor	C-090426	UF20-7-77-126	J. Utting, 1977
	Upper Windsor	C-090427	UF20-7-77-127	J. Utting, 1977
	Upper Windsor	C-090428	UF20-7-77-128	J. Utting, 1977
	Upper Windsor	C-090429	UF20-7-77-129	J. Utting, 1977
	Upper Windsor	C-090430	UF20-7-77-130	J. Utting, 1977
(b) South of Woody Cape	Upper Windsor	C-090431	UF19-7-77-116	J. Utting, 1977
(Capelin Cove)	Upper Windsor	C-090432	UF19-7-77-117	J. Utting, 1977
Searston Formation				
North of Grand Codroy River				
(a) Capelin Cove	Canso	C-097717	75-7-4	I. Knight, 1975
	Canso	C-090450	UF19-7-77-111	J. Utting, 1977
South of Grand Codroy River				
(a) 450 m south of Kennedy Point	Canso	C-097718	75-3-3	I. Knight, 1975
(b) 1.25 km south of Kennedy Point	Canso	C-090446	UF19-7-77-100	J. Utting, 1977
	Canso	C-090447	UF19-7-77-101	J. Utting, 1977
	Canso	C-090448	UF19-7-77-102	J. Utting, 1977

APPENDIX 2

Geological Survey of Canada and Royal Ontario Museum locality numbers, locations, latitude and longitude or grid references, and stratigraphic positions (numbers are listed in the same order as in Appendix 1).

Locality numbers[1]	Location	Latitude (°N) longitude (°W) (or grid reference)	Stratigraphic position (refers to single sample unless otherwise stated)
	NOVA SCOTIA		
D-1384	Port Hood Island, Inverness County, Cape Breton	46°01', 61°26'	Lower Windsor Group (Subzone B) and Upper Windsor Group (Subzones C and D) [see Figure 7 for sample horizons (34 samples)]
ROM-PHI-C1-1*	"	"	Upper Windsor Group (Subzones C and E) [see Figure 7 for sample horizons (13 samples)]
to			
ROM-PHI-C1-8*	"	"	
to			
ROM-PHI-C2-1*	"	"	
to			
ROM-PHI-C2-2*	"	"	
to			
ROM-PHI-E1-1*	"	"	
to			
ROM-PHI-E1-3*	"	"	
C-097701	Borehole K112, Lake Enon, Richmond County, Cape Breton	45°46'19", 60°34'37"	204.3 m from top of borehole; carbonate bed 1.5 m above base of "Enon formation"; Lower Windsor Group
"	"	"	215.05 m from top of borehole; carbonate bed 3.0 m above base of "Enon formation"; Lower Windsor Group
"	"	"	232.17 m from top of borehole; conglomerate and sandstone unit 3.23 m above base of "Enon formation"; Lower Windsor Group
C-097702	Borehole K116, Lake Enon, Richmond County, Cape Breton	45°46'09", 60°34'11"	33.13 m from top of borehole; sandstone unit at base of "Enon formation"; Lower Windsor Group
C-097703	Borehole K117, Lake Enon, Richmond County, Cape Breton	45"46'24", 60'34'50"	106.38 m from top of borehole; siltstone unit 109.73 m above base of "Uist formation"; Upper Windsor Group
"	"	"	138.29 m from top of borehole; from base of carbonate unit; 76.2 m above base of "Uist formation"; Upper Windsor Group
"	"	"	199.95 m from top of borehole; carbonate unit 15.2 m above base of "Uist formation"; Upper Windsor Group
D-1325	Borehole Noranda Exploration 4, Lake Enon, Cape Breton County, Cape Breton	Grand Narrows map sheet 11F15, 910773	23.01 m from top of borehole; 21.03 m bed of mudstone and gypsum; 34.49 m above top of uppermost carbonate bed; Windsor-Canso Group boundary beds

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[1] All samples are from the Geological Survey of Canada collection, except those indicated by an asterisk, which are from the Royal Ontario Museum collection.

Locality numbers[1]	Location	Latitude (°N) longitude (°W) (or grid reference)	Stratigraphic position (refers to single sample unless otherwise stated)
D-1325	Borehole Noranda Exploration 4, Lake Enon, Cape Breton County, Cape Breton	Grand Narrows map sheet 11F15, 910773	34.75 m from top of borehole; 21.03 m bed of mudstone and gypsum; 25.60 m above top of uppermost carbonate bed; Windsor-Canso Group boundary beds
"	"	"	37.19 m from top of borehole; 21.03 m bed of mudstone and gypsum; 22.86 m above top of uppermost carbonate bed; Windsor-Canso Group boundary beds
D-1332	Borehole Noranda Exploration 12, Lake Enon, Cape Breton County, Cape Breton	Grand Narrows map sheet 11F15, 891751	157.58 m from top of borehole; near top of 11.89 m laminated siltstone underlain by 8.53 m gypsiferous siltstone; Windsor-Canso Group boundary beds
"	"	"	162.15 m from top of borehole; near bottom of 11.89 m laminated siltstone underlain by 8.53 m gypsiferous siltstone; Windsor-Canso Group boundary beds
"	"	"	179.07 m from top of borehole; 35.66 m laminated siltstone; Windsor-Canso Group boundary beds
D-1014	Cape Dauphin, Cape Breton	46°21', 60°25'	Below B_2 limestone of Stacey (1953, p. 38); composite of 3 samples from 9 m beds of siltstone; Lower Windsor Group (3 samples)
C-090404	"	"	Sample from upper 1.5 m of 9 m bed described above; Lower Windsor Group
D-1014, JS 1-72-6; C-090402	"	"	0.3 m dark grey mudstone bed, 0.9 m below top of 24.4 m maroon (interlaminated with light blue) siltstone bed mentioned by Stacey (1953, p. 37); macrofaunal Subzone D; Upper Windsor Group (2 samples)
D-1014, JS1-72-8	"	"	Sample taken from 3 m interval immediately above 5.5 m bed of grey crystalline limestone (Stacey, 1953, p. 37); at base of macrofaunal Subzone E; Upper Windsor Group
C-097712	"	"	Dark grey to black shale bed 5.5 m above uppermost hard, light grey carbonate unit; Windsor-Canso Group boundary beds
GSC plant locality 1659	Frenchvale Brook, Balls Creek, NW arm Sydney Harbour, Cape Breton	46°10', 60°18'	Either from Lower Windsor or basal part of Subzone C of Upper Windsor Group (Barss, 1967, Pl. V-VI)
D-1370, 98-3	St. Ann's Bay, North Gut of St. Ann's, Victoria County, Cape Breton	46°12'19", 60°37'44"	Stream channel outcrop sample from above A_1 laminite, but below massive evaporite; Subzone A; Lower Windsor Group
D-1373, 10-6-6	North Shore Provincial Park, Victoria County, Cape Breton	46°24'49" 60°28'29"	350 m NNE of mouth of McDonald Brook; above A_1 laminite but below massive evaporite; Subzone A; Lower Windsor Group
D-1534, KA 21	Baddeck, Victoria County, Cape Breton	46°09', 61°11'	Near Baddeck Bridge, Baddeck; Windsor-Canso Group boundary

Locality numbers[1]	Location	Latitude (°N) longitude (°W) (or grid reference)	Stratigraphic position (refers to single sample unless otherwise stated)
D-1534, KA 63-6	Baddeck, Victoria County, Cape Breton	46°09', 61°11'	0.96 km north of Provincial Building in Baddeck at Cheveries Corner; Windsor-Canso Group boundary
D-1534, KA 63-D	"	"	0.8 km downstream from Baddeck Bridge; Windsor-Canso Group boundary
C-090418	Broad Cove, Inverness County, Cape Breton	46°17', 61°16'	19.2 m above the top of Windsor Group E_1 Limestone from 3 m grey siltstone bed in Hastings Formation; Windsor-Canso Group boundary beds
C-090419	"	"	160 m above sample C-090418 from grey shale immediately above 0.15 m stromatolitic limestone; Windsor-Canso Group boundary beds
D-1380	Lake Ainslie, Broad Cove River, Inverness County, Cape Breton	46°13'08", 61°17'38"	Sample from channel of Broad Cove River, 250 m downstream from the Canadian National Railway Bridge; 1.5 km SE of Inverness; from above A_1 laminite but below massive evaporite of Windsor Group; Subzone A; Lower Windsor Group
C-090406	Borehole SB-1, Shubenacadie Basin, Hants County	45°07', 63°20'	Lower Windsor Group (Subzones A and B) and Upper Windsor Group (Subzones C, D and E) and Windsor-Canso Group boundary beds; see Figure 9 for sample horizons (120 samples)
C-090407 to C-090417	Kennetcook River, Hants County	45°03', 64°07'	Type section of Kennetcook Limestone Member described by Bell (1929, p. 53) at confluence of Kennetcook and Avon rivers; 13.70 m of section sampled; Subzone E; Upper Windsor Group. One barren sample (C-090417) taken from 3.65 m of red brown siltstone and sandstone occurring at base of section beneath fault (11 samples)
C-097704	Knoydart Point, Antigonish County	45°42'05", 62°13'06"	Approximately 30 m above top of uppermost Windsor carbonate; grey buff carbonaceous sandstone intercalations in red brown siltstone; Windsor-Canso Group boundary beds
D-1010, JS-32-72-4 and JS-32-72-5	"	"	Immediately below the uppermost Windsor carbonate; Upper Windsor Group (2 samples)
C-097708	"	"	Uppermost Windsor carbonate at this locality is 15 to 18 m thick; sample was obtained from 0.025 m black shale 0.3 m above base of carbonate (west side of Headland); Upper Windsor Group
C-097709	"	"	0.075 m carbonate intercalations in grey shale 0.05 m below the base of carbonate mentioned for sample C-097708 (west side of Headland); Upper Windsor Group
C-097710	"	"	Probably equivalent to C-097709, but from east side of Headland; Upper Windsor Group
C-078245	Cheverie, Hants County	45°09', 64°11'30"	Alternations of shale and sandstone 3.0 m above pale grey grit forming Headland; Cheverie Formation type section, Horton Group

Locality numbers[1]	Location	Latitude (°N) longitude (°W) (or grid reference)	Stratigraphic position (refers to single sample unless otherwise stated)
Borehole Petro-Canada et al. St. Paul P-91	Cabot Strait	47°10'57.88", 60°13'36.83"	Depth 2195-2725 m, 3 samples of cuttings from Windsor Group
	QUÉBEC		
D-1481, 77-66-1	Île du Havre-aux-Maisons, Îles-de-la-Madeleine (Magdalen Islands)	Île aux Meules map sheet 11 N/5 927478	6 m siltstone unit within reddish tuffaceous beds; approximately equivalent to locality F2 of Sanschagrin (1964, p. 25); Subzone B; Lower Windsor Group
C-097719	"	"	400 m north of D-1481; from grey siltstone bed immediately below thin carbonate bed; Lower(?) Windsor Group
C-097720	"	"	100 m north of C-097719; from thin, dark grey mudstone band within purplish brown siltstone 8 m south of contact with volcanic beds; Lower(?) Windsor Group
C-097721	"	"	Similar to C-097720 but 6 m south of contact with volcanic beds; Lower(?) Windsor Group
C-090436	"	"	0.05 m of grey mudstone within reddish brown siltstone and gypsum 30 m east of locality F6 of Sanschagrin (1964); Lower(?) Windsor Group
C-090437	"	"	Thin, grey mudstone band at locality F6 of Sanschagrin (1964); Lower(?) Windsor Group
C-090438	"	"	Thin, dark grey mudstone 350 m east of C-090437; Lower(?) Windsor Group
C-090439	"	"	Thin, dark grey mudstone 450 m west of C-090438, but 20 m west of contact between reddish brown siltstone, mudstone and gypsum, and volcanic beds; Lower(?) Windsor Group
C-090440	"	"	Thin, grey mudstone west of C-090439, but immediately east of contact with volcanic rocks; Lower(?) Windsor Group
C-090441	"	"	Thin, grey mudstone at western contact between volcanic rocks and Windsor sediments; Lower(?) Windsor Group
D-1477, 77-58-5	Île du Havre Aubert, Anse à la Cabane, Îles-de-la-Madeleine (Magdalen Islands)	Havre Aubert map sheet 11 N/4 773294	Grey-black banded shale immediately west of the wharf at 763297
C-090441	Île Boudreau, Îles-de-la-Madeleine (Magdalen Islands)	47°32'30", 61°31'15"	Pale, dark grey calcareous shale in upper part of bed N of Sanschagrin (1964, p. 34); Subzone C; Upper Windsor Group
ROM-IDM-3-2*	"	"	45 m above contact of beds V and U of Sanschagrin (1964, Fig. 4), from 0.3 m siltstone in middle of bed V (beds overturned); Upper Windsor Group
ROM-IDM-3-3*	"	"	57 m above contact of beds V and U (beds overturned); Upper Windsor Group

Locality numbers[1]	Location	Latitude (°N) longitude (°W) (or grid reference)	Stratigraphic position (refers to single sample unless otherwise stated)
D-1438, 77-56-15	Île Boudreau, Îles-de-la-Madeleine (Magdalen Islands)	47°32'30", 61°31'15"	Younger(?) part of bed V of Sanschagrin (1964, Fig. 4, p. 34); Windsor-Canso Group boundary beds
	NEW BRUNSWICK		
D-1471, 77-44-6	Hopewell Cape, Albert County	45°48'56", 64°34'40"	Demoiselle Creek beds; 45 m below base of overlying conglomerate of Hopewell Group; sample from 0.9 m yellow-grey mottled siltstone and sandstone; below is a 0.6 m calcarenite; Lower Windsor Group
D-1471, 77-44-4	"	"	1.8 m mottled siltstone and sandstone immediately below 0.6 m calcarenite described for 77-44-6; below 1.8 m bed is 1.2 m red conglomerate; Lower Windsor Group
C-090434	"	"	0.02 m shale intercalation 0.3 m below base of conglomerate described for 77-44-4; Lower Windsor Group
D-1971	"	"	Thin mudstone unit 3.1 m above uppermost carbonate bed of the Demoiselle Creek beds; Lower Windsor Group
C-090401	Borehole Millstream no. 1, Kings County	45°42', 65°38'	Samples from 918.06, 919.58, 919.89, 920.50, 920.80, 921.71 and 922.63 m below top of borehole; Lower Windsor Group (7 samples)
	S.W. NEWFOUNDLAND		
C-097738	Codroy Island, Codroy Valley	47°52'15", 59°23'10"	Composite sample from 8.0 m of exposed limestone on southeast tip of Codroy Island; Subzone A; Lower Windsor Group
ROM-Shp-Cv-4-1*	Fischells Brook, St. George's Bay	Flat Bay map sheet 12 B/7	Basal 1.14 m of Ship Cove Formation; Subzone A; Lower Windsor Group (von Bitter and Plint-Geberl, 1982, Fig. 3, locality 4A, and Bell, 1948, p. 33)
ROM-Shp-Cv-Sp-1*	"	"	Basal 0.10-0.13 m of Ship Cove Formation; Subzone A; Lower Windsor Group (von Bitter and Plint-Geberl, 1982, Fig. 3, locality 4A)
ROM-Shp-Cv-Sp-2*	"	"	0.61-1.19 m above base of Ship Cove Formation; Subzone A; Lower Windsor Group (von Bitter and Plint-Geberl, 1982, Fig. 3)
ROM-Shp-Cv-4-2*	"	"	0.60-0.91 m interval 3.66 m above base of Ship Cove Formation; Subzone A; Lower Windsor Group (von Bitter and Plint-Geberl, 1982, Fig. 3, locality 4A)
ROM-Shp-Cv-4-3*	"	"	Uppermost 0.91-122 m of the exposure of Ship Cove Formation; Subzone A; Lower Windsor Group (von Bitter and Plint-Geberl, 1982, Fig 3)
ROM-Agu-1-1*	Aguathuna, Port au Port Peninsula	Stephenville map sheet 12 B/10 1:50,000	From the base of the Carboniferous limestone; Subzone A; Lower Windsor Group (von Bitter and Plint-Geberl, 1982, Fig. 5)

Locality numbers[1]	Location	Latitude (°N) longitude (°W) (or grid reference)	Stratigraphic position (refers to single sample unless otherwise stated)
ROM-Agu-1-2*	Aguathuna, Port au Port Peninsula	Stephenville map sheet 12 B/10 1:50,000	From the apparent top of the Carboniferous limestone; Subzone A; Lower Windsor Group (von Bitter and Plint-Geberl, 1982, Fig. 5)
ROM-Bos-1-5*	Boswarlos, Port au Port Peninsula	"	1.32 m of limestone at top of section; Subzone A; Lower Windsor Group (von Bitter and Plint-Geberl, 1982, Fig. 5; Bell, 1948, p. 34)
ROM-Bos-1-3*	"	"	Thin bedded limestone 0.76 m thick with light grey, shaly interbeds 0.27 m above base of section; Subzone A; Lower Windsor Group (von Bitter and Plint-Geberl, 1982, Fig. 5; Bell, 1948, p. 34)
ROM-Bos-1-2*	"	"	0.18 m of black shale 0.08 m above base of section; Subzone A; Lower Windsor Group (von Bitter and Plint-Geberl, 1982, Fig. 5; Bell, 1948, p. 34)
ROM-Bos-1-1*	"	"	0.08 m of thin bedded medium grey limestone at base of section; Subzone A; Lower Windsor Group (von Bitter and Plint-Geberl, 1982, Fig. 5; Bell, 1948, p. 34)
ROM-Bos-1-2*	Romaines Brook, Port au Port Peninsula	"	0.13 m of medium bedded, fine grained, grey and nonlaminated limestone at base of section; Subzone A; Lower Windsor Group (von Bitter and Plint-Geberl, 1982, Fig. 5)
ROM-ROM-1-3*	"	"	0.46 m of grey, medium to thick bedded limestone 1.22 m above base; Subzone A; Lower Windsor Group (von Bitter and Plint-Geberl, 1982, Fig. 5)
C-097731	Between Codroy and Woodville, Codroy Valley	47°52'30", 59°23'	1.0 m grey shale within a gypsum bed possibly equivalent to, or slightly lower than bed 3 of Bell (1948, p. 18); Lower Windsor Group
C-097732	"	"	2.0 m dark grey shale within gypsum of bed 3 of Bell (1948, p. 18); Lower Windsor Group
C-097733	"	"	Grey siltstone unit in bed 4 of Bell (1948, p. 18); 6.0 m above top of bed 3; Lower Windsor Group
C-097734	"	"	Dark grey argillaceous bed from upper part of bed 4 of Bell (1948, p. 18); Lower Windsor Group
C-097735	Woodville village, Codroy Valley	47°51'30", 59°22'	Bed 20 of Bell (1948, p. 1), collected from gypsiferous shale 1.0 m below base of bed 21; Lower Windsor Group
C-097736	"	"	1.0 m dark grey shale bed in middle part of bed 25 of Bell (1948, p. 17); Lower Windsor Group
C-097737	"	"	1.5 m dark grey shale bed within bed 36 of Bell (1948, p. 17); Lower Windsor Group
C-090420	Mollichignick, Codroy Valley	47°53'30", 59°06'30"	14.02-14.78 m from top of section; from shale bed with sandy intercalations; Upper(?) Windsor Group

Locality numbers[1]	Location	Latitude (°N) longitude (°W) (or grid reference)	Stratigraphic position (refers to single sample unless otherwise stated)
C-090421	Mollichignick, Codroy Valley	47°53'30", 59°06'30"	14.78-17.83 m from top of section; from alternating thin beds of black shale and grey dolomitic sandstone; Lower(?) Windsor Group
C-090422	"	"	28.50-28.65 m from top of section; black shale; Lower(?) Windsor Group
C-090423	"	"	28.95-29.10 m from top of section; black shale; Lower(?) Windsor Group
C-090424	"	"	29.32-29.77 m from top of section; shale bed with thin intercalations (0.06 m) of nodular calcareous units; Lower(?) Windsor Group
C-090425	"	"	30.15-30.45 m from top of section; alternation of fine, micaceous, light grey sandstone with intercalations of shale approximately 0.05 m thick; Lower(?) Windsor Group
ROM-Heath-2-9*	Heatherton, St. Georges's Bay	Flat Bay map sheet 12 B/7 1:50,000	22.5 m below base of Heatherton limestone described by Bell (1948, p. 31), from 0.20 m earthy, cream weathering limestone; Subzone B, *Cavusgnathus* Zone; Lower Windsor Group (von Bitter and Plint-Geberl, 1982, Fig. 3, locality 6B; Fig. 6; Bell, 1948, Section K)
C-090426	Woody Cape	47°51'30", 59°22'	Equivalent to bed 54 of Bell (1948, p. 16); 6.1 m dark grey calcareous siltstone, with alternations of thin, greenish grey fine grained sandstone; Upper Windsor Group
C-090427	"	"	Equivalent to bed 56 of Bell (1948, p. 16); 20 m dark grey shale, mudstone and siltstone with calcareous bands; Upper Windsor Group
C-090428	"	"	Equivalent to bed 60 of Bell (1948, p. 16); 27 m greenish grey shale and arenaceous siltstone; dark grey argillaceous shale; thin gypsum bands; Upper Windsor Group
C-090429	"	"	Equivalent to bed 105 of Bell (1948, p. 15); 3.35 m dark grey argillo-arenaceous shale; Upper Windsor Group
C-090430	"	"	100 m south-southwest of C-090429; massive sandstone with shaly intercalations; Upper Windsor Group
C-090431	South of Woody Cape	47°50'30", 59°22'	44 m from base of section; 171 m from top of section; 3 m dark grey to black shale; Upper Windsor Group
C-090432	"	"	60 m from base of section; 115 m from top of section; 1 m thick black shale overlying redbed; Upper Windsor Group
C-097717	Capelin Cove	47°50'25", 59°22'15"	Approximately 900 m east-northeast of Stormy Point; green-grey and red sandstone and conglomerate, and red, green, blue-grey, grey and black siltstone and mudstone; Canso Group

Locality numbers[1]	Location	Latitude (°N) longitude (°W) (or grid reference)	Stratigraphic position (refers to single sample unless otherwise stated)
C-090450	Stormy Point	47°50'25", 59°22'15"	Approximately 850 m east-northeast of Stormy Point; grey, crossbedded, medium grained sandstone with thin grey shale intercalations; sample from 0.15-0.30 m dark grey shale; Windsor-Canso Group boundary beds
C-097718	Kennedy Point	47°49'08", 59°19'45"	Approximately 450 m south of Kennedy Point; Dark grey shale and siltstone alternating with grey, pebbly sandstone, grey, fine grained sandstone and purple-grey, fine grained sandstone; Canso Group
C-090446 C-090447	Kennedy Point	47°49'08", 59°20'00"	Approximately 1.25 km south of Kennedy Point; 3.05-4.88 m from top of section; dark grey lutite with thin, micaceous sandstone intercalations; C-090446 from upper part of bed; C-090447 from lower part (2 samples); Canso Group
C-090448	"	"	9.15-10.67 m from top of section; grey, fine grained sandstone and lutite; Canso Group

APPENDIX 3

Detailed assemblage lists

In Appendix 3, details of the assemblages are given to supplement the qualitative and quantitative data given in the vertical distribution charts (see Figures 7-10). Collectively this information forms the basis for the concurrent range zones formally proposed in the section on stratigraphic palynology. Also, details are given concerning the respective localities, the beds studied, the stratigraphic position of samples, the nature of the stratigraphic control, and the miospore zone to which the beds have been assigned. Information concerning curation numbers, field or borehole numbers, and the name of the collector are given in Appendices 1 and 2. The Nova Scotian localities are dealt with first, followed by those from Quebec, New Brunswick, and Newfoundland.

NOVA SCOTIA (see Figures 1, 2)

The localities discussed first are from Cape Breton Island, followed by those from the mainland of Nova Scotia.

A) Cape Breton Island

a) Port Hood Island (see Figure 2); Inverness County

The Port Hood Island section is situated on the north shore of the island and was considered by Stacy (1953, pp. 31-36) to be one of the best Windsor Group exposures in the region. This section is GSC locality D-1384, latitude 46°01'N, longitude 61°26'W. Thirty-four dark grey, argillaceous samples were collected from the Windsor Group (see Figure 7; details of the stratigraphy are from P.S. Giles, pers. comm., 1976). In addition, 13 carbonate samples from the Upper Windsor Group were investigated [these had been collected by P.H. von Bitter (1976) for his work on conodonts, and the organic residues were made available for palynological study]. The samples came from units C_1 and C_2 (macrofaunal Subzone C) and E_1 (macro-faunal Subzone E) of Stacy (1953). Qualitative data for the miospore assemblages from this section are given in Figure 7 and quantitative data in Figure 8.

Lower Windsor. The interval from the base of the section (0m) to 298 m (samples D-1384, 1-13) was attributed to macrofaunal Subzone B by Stacy (1953), and the miospore assemblages (see Figures 7, 8) may be assigned to the NS Zone.

Concurrent range zone: NS Zone.

Upper Windsor. The interval 298-430 m (samples D-1384, 14-21; C_1, 1-8, C_2, 1-2) was attributed to macrofaunal Subzone C by Stacy (1953); the interval 430-565 m (samples D-1384, 22-34) to Subzone D and the interval 565-579 m (samples E_1, 1-3) to Subzone E.

The miospore assemblages (see Figures 7, 8) may be assigned to the AT Zone.

b) Lake Enon Area (see Figure 2); Cape Breton and Richmond counties, Cape Breton Island

1. Boreholes K112, K116 and K117 of Kaiser Celestite Ltd. The stratigraphic data and formation names used for this locality are in the sense of Boehner (1981, Fig. 4). Some of the formation names have not been formally proposed and are therefore shown in quotation marks. The nomenclature used is after Crowell (in Boehner, 1981) and after Forgeron (*ibid.*) and is summarized below.

Upper Windsor Group	Undifferentiated
Lower Windsor Group	"Uist formation" "Loch Lomond formation" B_2 Limestone formation "Enon formation" Grantmire Formation

i) Borehole K112, GSC locality C-097701, latitude 45°46'19"N, longitude 60°34'37"W.

Sample depth 204.3 m (from top of borehole).

The sample was taken from the base of a carbonate bed 1.5 m above the base of the "Enon formation".

The preservation of spores is very poor, but the following species were identified: *Convolutispora vermiformis*, *Crassispora trychera*, *Leiosphaeridia*? sp. A, *Punctatisporites planus* and *Rugospora minuta*. *Leiosphaeridia* sp. A is abundant.

Concurrent range zone: NS Zone.

Sample depth 215.05 m (from top of borehole).

The sample was taken from a carbonate bed 3.0 m above the base of the "Enon formation".

The preservation of spores is poor but the following species were identified: *Convolutispora vermiformis*, *Crassispora trychera*, *Punctatisporites irrasus*, *Punctatisporites planus*, *Retusotriletes incohatus*, *Rugospora minuta* and *Schopfites claviger*.

Concurrent range zone: NS Zone.

Sample depth 232.17 m (from the top of the borehole).

The sample was taken from a conglomerate and sandstone unit 3.23 m above the base of the "Enon formation".

Identifications: *Convolutispora mellita, Convolutispora tessellata, Convolutispora vermiformis, Crassispora trychera, Densosporites columbaris, Leiosphaeridia*? sp. A, *Punctatisporites irrasus, Punctatisporites planus, Raistrickia clavata, Retusotriletes incohatus, Rugospora minuta, Schopfites claviger, Spelaeotriletes pretiosus* var. *bellii, Vallatisporites ciliaris* and *Verrucosisporites papulosus. Leiosphaeridia* sp. A is abundant.

Concurrent range zone: NS Zone.

ii) Borehole K116, GSC locality C-097702, latitude 45°46'09"N, longitude 60°34'11"W.

Sample depth 33.13 m (from top of borehole).

The sample was taken from a sandstone unit at the base of the "Enon formation".

Identifications: *Auroraspora macra, Convolutispora tessellata, Convolutispora vermiformis, Crassispora trychera, Discernisporites micromanifestus, Punctatisporites irrasus, Punctatisporites planus, Retusotriletes incohatus, Rugospora minuta, Spelaeotriletes pretiosus* var. *bellii* and *Verrucosisporites papulosus.*

Concurrent range zone: NS Zone.

iii) Borehole K117, GSC locality C-097703, latitude 45°46'24"N, longitude 60°34'50"W.

Sample depth 106.38 m (from the top of borehole).

The sample was taken from a siltstone unit 109.73 m above the base of the "Uist formation".

Identifications: *Auroraspora solisortus, Convolutispora vermiformis, Crassispora trychera, Densosporites columbaris, Dictyotriletes odontolophos, Knoxisporites probolos, Leiotriletes ornatus, Punctatisporites irrasus, Punctatisporites planus, Raistrickia magdalena, Retusotriletes incohatus, Rugospora minuta, Schopfipollenites acadiensis, Schopfites claviger* and *Spelaeotriletes pretiosus* var. *bellii.*

Concurrent range zone. AT Zone.

Sample depth 138.29 m (from the top of the borehole).

The sample was taken from the base of a carbonate unit 76.2 m above the base of the "Uist formation".

Identifications: *Auroraspora macra, Convolutispora vermiformis, Crassispora trychera, Dictyotriletes odontolophos, Discernisporites micromanifestus, Grandispora uncata, Knoxisporites probolos, Knoxisporites stephanephorus, Leiotriletes ornatus, Leiotriletes inermis, Punctatisporites irrasus, Punctatisporites planus, Pustulatisporites multicapitis, Raistrickia clavata, Raistrickia magdalena, Retusotriletes incohatus, Rugospora minuta, Rugospora polyptycha, Schopfipollenites acadiensis, Schopfites claviger, Secarisporites lobatus, Spelaeotriletes pretiosus* var. *bellii, Verrucosisporites morulatus* and *Verrucosisporites nitidus.*

Concurrent range zone: AT Zone.

Sample depth 199.95 m (from the top of the borehole).

The sample was taken from a carbonate unit 15.2 m above the base of the "Uist formation".

Identifications: *Auroraspora macra, Auroraspora solisortus, Convolutispora tessellata, Convolutispora vermiformis, Crassispora trychera, Cristatisporites submarginatus, Dictyotriletes odontolophos, Granulatisporites tuberculatus, Knoxisporites stephanephorus, Leiotriletes inermis, Punctatisporites irrasus, Punctatisporites planus, Pustulatisporites multicapitis, Raistrickia clavata, Retusotriletes incohatus, Rugospora minuta, Schopfites claviger, Spelaeotriletes pretiosus* var. *bellii, Vallatisporites ciliaris* and *Verrucosisporites morulatus.*

Concurrent range zone: AT Zone

2. Boreholes Noranda Exploration 4, GSC locality D-1325, and Noranda Exploration 12, GSC locality D-1332.

i) Borehole Noranda Exploration 4, GSC locality D-1325; topographic sheet Grand Narrows, 11F15, grid reference 910773.

Sample depth 23.01 m (from top of borehole; sample no. K60).

The sample was taken 34.49 m above the top of the uppermost carbonate bed of the Windsor Group, from a 21.03 m thick bed of mudstone with gypsum.

Identifications: *Convolutispora labyrinthea, Convolutispora mellita, Convolutispora tessellata, Crassispora trychera, Granulatisporites tuberculatus, Knoxisporites probolos, Knoxisporites stephanephorus, Knoxisporites triradiatus, Lycospora noctuina* var. *noctuina, Micrhystridium*? sp., *Punctatisporites irrasus, Punctatisporites planus, Raistrickia baculosa, Raistrickia ponderosa, Retusotriletes incohatus, Rugospora corporata* var. *verrucosa, Rugospora minuta, Rugospora polyptycha, Schopfipollenites acadiensis, Schopfites claviger, Schulzospora bilunata, Scutulum trisupplementum, Spelaeotriletes pretiosus* var. *windsorensis, Tricidarisporites arcuatus* and *Vallatisporites ciliaris.*

Concurrent range zone: SM Zone.

Sample depth 34.75 m (from top of borehole; sample no. K4).

The sample was taken 25.60 m above the top of the uppermost carbonate bed of the Windsor Group, from a 21.03 m thick bed of mudstone with gypsum.

Identifications: *Convolutispora labyrinthea, Convolutispora mellita, Convolutispora tessellata, Convolutispora vermiformis, Crassispora trychera, Cristatisporites submarginatus, Grandispora spinosa, Grandispora uncata, Granulatisporites tuberculatus, Knoxisporites probolos, Knoxisporites stephanephorus, Knoxisporites triradiatus, Leiotriletes inermis, Lycospora noctuina* var. *noctuina, Punctatisporites irrasus, Punctatisporites minutus, Punctatisporites planus, Raistrickia magdalena, Retusotriletes incohatus, Rugospora minuta, Schopfipollenites acadiensis, Schopfites claviger, Schulzospora bilunata, Spelaeotriletes pretiosus* var. *windsorensis* and *Verrucosisporites morulatus.*

Concurrent range zone: SM Zone.

Sample depth 37.19 m (from top of borehole; sample no. K5).

The sample was taken 22.86 m above the top of the uppermost carbonate bed of the Windsor Group, from a 21.03 m thick bed of mudstone with gypsum.

Identifications: *Convolutispora labyrinthea, Crassispora trychera, Grandispora spinosa, Grandispora uncata, Knoxisporites stephanephorus, Knoxisporites triradiatus, Lycospora noctuina* var. *noctuina, Punctatisporites irrasus, Punctatisporites planus, Retusotriletes incohatus, Rugospora corporata* var. *verrucosa, Rugospora minuta, Schopfipollenites acadiensis, Schopfites claviger* and *Schulzospora bilunata.*

Concurrent range zone: SM Zone.

ii) Borehole Noranda Exploration 12, GSC locality D-1332, topographic sheet Grand Narrows, 11F15, grid reference 891751.

Sample depth 157.58 m (from top of borehole; sample no. K54).

The sample was taken from an 11.89 m bed of laminated siltstone, which is underlain by 8.53 m of gypsiferous siltstone.

Identifications: *Convolutispora labyrinthea, Convolutispora mellita, Convolutispora tessellata, Convolutispora vermiformis, Crassispora trychera, Grandispora spinosa, Granulatisporites tuberculatus, Knoxisporites probolos, Knoxisporites stephanephorus, Knoxisporites triradiatus, Punctatisporites planus, Retusotriletes incohatus, Rugospora minuta, Schopfipollenites acadiensis, Schopfites claviger, Spelaeotriletes pretiosus* var. *windsorensis* and *Verrucosisporites morulatus.*

Concurrent range zone: SM Zone.

Sample depth 162.15 m (from top of borehole; sample no. K55).

The sample was taken from an 11.89 m bed of laminated siltstone, which is underlain by 8.53 m of gypsiferous siltstone.

Identifications: *Crassispora trychera, Ibrahimispores magnificus, Punctatisporites irrasus, Punctatisporites planus, Retusotriletes incohatus, Rugospora minuta, Rugospora polyptycha, Schopfipollenites acadiensis, Schopfites claviger* and *Spelaeotriletes pretiosus* var. *windsorensis.*

Concurrent range zone: SM Zone.

Sample depth 179.07 m (from top of borehole; sample no. K57).

The sample was taken from a 35.66 m bed of laminated siltstone with minor layered anhydrite, underlying 8.53 m of gypsiferous siltstone mentioned in samples from 157.58 and 162.15 m.

Identifications: *Auroraspora macra, Convolutispora mellita, Crassispora trychera, Grandispora spinosa, Granulatisporites tuberculatus, Punctatisporites irrasus, Punctatisporites planus, Retusotriletes incohatus, Rugospora minuta, Rugospora polyptycha, Schopfipollenites acadiensis* and *Schopfites claviger.*

Concurrent range zone: SM Zone.

c) *Cape Dauphin area (see Figure 2); Victoria County. Cape Dauphin cliff section (see Stacy, 1953, pp. 36-38), latitude 46°21'N, longitude 60°25'W*

i) GSC locality D-1014-JS-1-72, 0-30 ft. (0-9 m).

This sample represents a composite of three samples below the B_2 limestone of the Windsor Group described by Stacy (1953, p. 38) as "±30 feet. Poorly exposed. Small patches of maroon siltstone with blue mottling".

Identifications: *Auroraspora macra, Calamospora parva, Colatisporites decorus, Convolutispora labyrinthea, Convolutispora tessellata, Crassispora trychera, Densosporites columbaris, Discernisporites micromanifestus, Lycospora noctuina* var. *noctuina, Punctatisporites irrasus, Punctatisporites planus, Retusotriletes incohatus, Rugospora minuta, Vallatisporites ciliaris* and *Verrucosisporites morulatus.*

Concurrent range zone: NS Zone.

ii) GSC locality C-090404. This sample was taken from the top 1.5 m of the bed described above for GSC locality D-1014, and comes from a dark grey mudstone interval immediately below the B_2 limestone. Quantitative data for this sample are shown in Figure 10.

Identifications: *Auroraspora macra, Colatisporites decorus, Crassispora trychera, Densosporites columbaris, Leiotriletes ornatus, Punctatisporites irrasus, Punctatisporites planus, Raistrickia clavata, Retusotriletes incohatus, Rugospora minuta, Spelaeotriletes pretiosus* var. *bellii, Vallatisporites ciliaris, Verrucosisporites morulatus, Verrucosisporites nitidus* and *Verrucosisporites papulosus.*

Concurrent range zone: NS Zone.

iii) D-1014-JS-1-72-6 and GSC locality C-090402. These samples were obtained from the same interval from the uppermost part of the bed described by Stacy as "80 feet. Poorly exposed maroon siltstone in part interbedded with light blue". The samples come from a 0.3 m thick, very dark grey mudstone bed 0.9 m below the top of the maroon siltstone bed. This unit was assigned to the Windsor Group macrofaunal Subzone D by Stacy (1953, p. 37). Quantitative data for this sample are shown in Figure 10.

Identifications: *Calamospora parva*, *Colatisporites decorus*, *Convolutispora labyrinthea*, *Convolutispora mellita*, *Convolutispora tessellata*, *Convolutispora vermiformis*, *Crassispora trychera*, *Cristatisporites submarginatus*, *Dictyotriletes odontolophos*, *Discernisporites micromanifestus*, *Grandispora uncata*, *Granulatisporites tuberculatus*, *Knoxisporites probolos*, *Knoxisporites stephanephorus*, *Leiotriletes inermis*, *Leiotriletes ornatus*, *Lycospora noctuina* var. *noctuina*, *Punctatisporites irrasus*, *Punctatisporites planus*, *Pustulatisporites multicapitis*, *Raistrickia clavata*, *Raistrickia magdalena*, *Retusotriletes incohatus*, *Rugospora minuta*, *Rugospora polyptycha*, *Schopfipollenites acadiensis*, *Schopfites claviger*, *Scutulum trisupplementum*, *Spelaeotriletes pretiosus* var. *windsorensis*, *Spelaeotriletes tuberosus*, *Verrucosisporites morulatus*, *Verrucosisporites nitidus* and *Verrucosisporites papulosus*.

Concurrent range zone: AT Zone.

iv) GSC locality D-1014-JS-1-72-8. From a 3 m thick interval immediately above a unit described by Stacy (1953, p. 37) as "18 feet of grey crystalline limestone. . .". The latter was at the base of macrofaunal Subzone E.

Identifications: *Convolutispora labyrinthea*, *Convolutispora tessellata*, *Convolutispora vermiformis*, *Crassispora trychera*, *Punctatisporites planus*, *Retusotriletes incohatus*, *Rugospora minuta*, *Schofipollenites acadiensis*, *Schopfites claviger*, *Spelaeotriletes pretiosus* var. *windsorensis*, *Spelaeotriletes tuberosus* and *Verrucosisporites morulatus*.

Concurrent range zone: AT Zone.

v) GSC locality C-097712. This sample was collected from a dark grey to black shale bed approximately 5.50 m above the uppermost, hard, light grey carbonate unit of the Windsor Group. Quantitative data for this sample are shown in Figure 10.

Identifications: *Colatisporites decorus*, *Convolutispora labyrinthea*, *Convolutispora mellita*, *Convolutispora tessellata*, *Convolutispora vermiformis*, *Crassispora trychera*, *Cristatisporites submarginatus*, *Dictyotriletes odontolophos*, *Discernisporites micromanifestus*, *Ibrahimispores magnificus*, *Knoxisporites probolos*, *Knoxisporites stephanephorus*, *Leiotriletes ornatus*, *Punctatisporites planus*, *Raistrickia baculosa*, *Raistrickia magdalena*, *Raistrickia nigra*, *Retusotriletes incohatus*, *Rugospora corporata* var. *verrucosa*, *Rugospora minuta*, *Schopfipollenites acadiensis*, *Schopfites claviger*, *Verrucosisporites morulatus* and *Verrucosisporites papulosus*.

Concurrent range zone: SM Zone.

d) Frenchvale Brook (see Figure 2); Balls Creek, Northwest Arm of Sydney Harbour, Cape Breton County

i) GSC plant locality 1659; latitude 46°10'N, longitude 60°18'W. This sample was thought to come either from the Lower Windsor or the basal part of the Upper Windsor macrofaunal Subzone C (pers. comm., W.A. Bell with M.S. Barss). Specimens from this sample were illustrated by Barss (1967, Plates V-VI).

Identifications: *Auroraspora macra*, *Calamospora parva*, *Chomotriletes multivittatus*, *Colatisporites decorus*, *Convolutispora tessellata*, *Crassispora trychera*, *Densosporites columbaris*, *Discernisporites micromanifestus*, *Leiotriletes inermis*, *Lycospora noctuina* var. *noctuina*, *Punctatisporites irrasus*, *Punctatisporites planus*, *Retusotriletes incohatus*, *Rugospora minuta*, *Rugospora polyptycha*, *Schopfites claviger*, *Spelaeotriletes pretiosus* var. *bellii* and *Verrucosisporites morulatus*. The assemblage is dominated by *Crassispora trychera*, *Punctatisporites irrasus*, *Punctatisporites planus*, *Retusotriletes incohatus* and *Rugospora minuta*.

Concurrent range zone: NS Zone.

e) St. Ann's Bay (see Figure 2); North Gut of St. Ann's, Victoria County

i) GSC locality D-1370, 98-3; topographic sheet Baddeck 11K/2, grid reference 830195, latitude 46°12'19"N, longitude 60°37'44"W. The sample was obtained from an outcrop along the channel of a stream that flows into the southwest end of the North Gut of St. Ann's harbour; the locality is approximately 400 m west-southwest of Cabot Trail Bridge. The sample was from above the A_1 laminite, but below the massive evaporite of the Windsor Group.

Identifications: *Auroraspora macra*, *Biannulatisporites simplex*, *Calamospora parva*, *Convolutispora labyrinthea*, *Convolutispora tessellata*, *Crassispora trychera*, *Discernisporites micromanifestus*, *Leiotriletes inermis*, *Punctatisporites irrasus*, *Punctatisporites minutus*, *Punctatisporites planus*, *Raistrickia clavata*, *Retusotriletes incohatus*, *Rugospora minuta*, *Rugospora polyptycha*, *Schopfites claviger*, *Spelaeotriletes pretiosus* var. *bellii*, *Vallatisporites ciliaris*, *Verrucosisporites morulatus* and *Verrucosisporites nitidus*.

Concurrent range zone: NS Zone.

f) North Shore Provincial Park (see Figure 2); Victoria County

i) GSC locality D-1373, 106-6; topographic sheet Bras d'Or 11K/8, grid reference 6940.51430, latitude 46°24'49"N, longitude 60°28'29"W. Sample collected from coastal section 350 m north-northeast of mouth of McDonald Brook. The sample comes from above the A_1 laminite, but below the massive evaporite of the Windsor Group, i.e. Subzone A of Bell (1929).

Identifications: *Convolutispora vermiformis*, *Crassispora trychera*, *Densosporites columbaris*, *Discernisporites micromanifestus*, *Punctatisporites irrasus*, *Punctatisporites planus*, *Retusotriletes incohatus*, *Rugospora minuta* and *Schopfites claviger*.

Concurrent range zone: NS Zone.

g) Baddeck (see Figure 2); Victoria County

i) GSC locality D-1534, KA 21; latitude 46°09'N, longitude 61°11'W. Near Baddeck Bridge, Baddeck; from the Windsor/Canso Group boundary beds.

Identifications: *Calamospora parva*, *Convolutispora labyrinthea*, *Convolutispora mellita*, *Convolutispora tessellata*, *Crassispora trychera*, *Cristatisporites submarginatus*, *Ibrahimispores magnificus*, *Knoxisporites probolos*, *Knoxisporites stephanephorus*, *Knoxisporites triradiatus*, *Leiotriletes ornatus*, *Punctatisporites planus*, *Raistrickia baculosa*, *Raistrickia magdalena*, *Retusotriletes incohatus*, *Rugospora minuta*, *Schopfipollenites acadiensis*, *Schopfites claviger*, *Schulzospora bilunata*, *Vallatisporites ciliaris* and *Verrucosisporites morulatus*.

Concurrent range zone: SM Zone.

ii) GSC locality D-1534, KA 63-6; was collected approximately 0.96 km north of Provincial Building in Baddeck at Cheverie's Corner; from the Windsor/Canso Group boundary beds.

Identifications: *Acanthotriletes hacquebardii*, *Auroraspora macra*, *Colatisporites decorus*, *Convolutispora labyrinthea*, *Convolutispora mellita*, *Convolutispora tessellata*, *Crassispora trychera*, *Dictyotriletes odontolophos*, *Discernisporites micromanifestus*, *Ibrahimispores magnificus*, *Knoxisporites probolos*, *Knoxisporites stephanephorus*, *Leiotriletes ornatus*, *Lycospora noctuina* var. *noctuina*, *Punctatisporites irrasus*, *Punctatisporites planus*, *Pustulatisporites multicapitis*, *Raistrickia baculosa*, *Raistrickia clavata*, *Retusotriletes incohatus*, *Rugospora corporata* var. *verrucosa*, *Rugospora minuta*, *Schopfipollenites acadiensis*, *Schopfites claviger*, *Spelaeotriletes pretiosus* var. *windsorensis*, *Vallatisporites ciliaris* and *Verrucosisporites morulatus*.

Concurrent range zone: SM Zone.

iii) GSC locality D-1534, KA 63-D; approximately 0.8 km downstream from Baddeck Bridge, from the Windsor/Canso Group boundary.

Identifications: *Colatisporites decorus*, *Convolutispora labyrinthea*, *Convolutispora mellita*, *Discernisporites micromanifestus*, *Knoxisporites stephanephorus*, *Knoxisporites triradiatus*, *Lycospora noctuina* var. *noctuina*, *Punctatisporites planus*, *Raistrickia baculosa*, *Raistrickia magdalena*, *Retusotriletes incohatus*, *Rugospora corporata* var. *verrucosa*, *Rugospora minuta*, *Schopfipollenites acadiensis*, *Schopfites claviger*, *Vallatisporites ciliaris* and *Verrucosisporites morulatus*.

Concurrent range zone: SM Zone.

h) Broad Cove (see Figure 2); Inverness County

i) GSC locality C-090418, latitude 46°17'N, longitude 61°16'W. The sample was taken 19.20 m above the top of the Windsor Group E_1 limestone in the cliff section at Broad Cove. The sample came from 3 m of grey siltstone within the Hastings Formation proposed by Belt (1965).

Identifications: *Auroraspora macra*, *Convolutispora tessellata*, *Crassispora trychera*, *Knoxisporites triradiatus*, *Lycospora noctuina* var. *noctuina*, *Retusotriletes incohatus*, *Rugospora corporata* var. *verrucosa*, *Rugospora minuta*, *Rugospora polyptycha*, *Schopfipollenites acadiensis*, *Schopfites claviger* and *Schulzospora bilunata*.

Concurrent range zone: SM Zone.

ii) GSC locality C-090419, latitude 46°17'N, longitude 61°16'W. The sample was taken from the cliff 160 m north of GSC locality C-090418, from a grey shale immediately above a 0.15 m thick stromatolitic limestone.

Identifications: *Crassispora trychera*, *Ibrahimispores magnificus*, *Knoxisporites stephanephorus*, *Knoxisporites triradiatus*, *Retusotriletes incohatus*, *Schopfipollenites acadiensis*, *Schopfites claviger* and *Vallatisporites ciliaris*.

Concurrent range zone: SM Zone.

i) Lake Ainslie (see Figure 2); Broad Cove River, Inverness County

i) GSC locality D-1380, 116-3. Lake Ainslie topographic sheet 11K/3, grid reference 316195, latitude 46°13'08"N, longitude 61°17'38"W. The sample was collected from an outcrop along the channel of the Broad Cove River 250 m downstream from the Canadian National Railway Bridge, approximately 1.5 km southeast of Inverness. The sample comes from above the A_1 laminite, but below the massive evaporite of the Windsor Group.

Identifications: *Crassispora trychera*, *Densosporites columbaris*, *Punctatisporites irrasus*, *Punctatisporites planus*, *Retusotriletes incohatus*, *Rugospora minuta* and *Schopfites claviger*.

Concurrent range zone: NS Zone.

B) Mainland Nova Scotia

a) Shubenacadie Basin, Hants County

Borehole United States Borax and Chemical Corporation, Stewiacke, SB-1 (see Figures 2, 9, 10). Core was taken for the total depth (888.19 m) of this well.

i) GSC locality C-090406, latitude 45°07'N, longitude 63°20'W. Miospore assemblages found in the 120 core samples and the miospore zones to which these assemblages were assigned are shown in Figure 9; quantitative data are shown in Figure 10. A general description of the results was given by Utting (1980), when an informal zonal nomenclature was used. The formational names used are those shown on the geological map of the province of Nova Scotia (Keppie, 1979), and were proposed in an open file release of the Nova Scotia Department of Mines and Energy by Giles and Boehner (1979). Those names not yet formally proposed are shown in quotation marks.

In the following section, the palynological results obtained are summarized, commencing at the bottom of the well. The sample depth is given in metres from the top of the borehole.

885.50-888.19 m: Horton Group. No identifiable fossils were found.

676.96-885.50 m: Macumber Formation, "Carrolls Corner formation" and lower and middle parts of the "Stewiacke formation". The preservation of spores is very poor. The assemblages recorded may be tentatively assigned to the NS Zone.

325.37-676.96 m: upper part of the "Stewiacke formation" and the "MacDonald Road formation". The assemblages from this interval may be assigned to the NS Zone.

184.40-325.37 m: "Green Oaks formation". This unit may be assigned to the CT Zone.

120.00-184.40 m: lower part of the "Watering Brook formation". The samples from this interval contain occasional identifiable specimens.

51.21-120.00 m: upper part of the "Watering Brook formation". This unit may be assigned to the SM Zone.

b) Kennetcook River area (see Figure 2); Hants County

The type section of the Kennetcook Limestone Member of the Windsor Group was described by Bell (1929, p. 53) and is located at the confluence of the Kennetcook and Avon rivers (latitude 45°03'N, longitude 64°07'W). This unit was assigned to the Windsor Group macrofaunal Subzone E by Bell.

Approximately 17 m of the section were sampled and the stratigraphic positions of samples C-090407 to C-090417 are given below:

Top of section (approximate measurements in metres)

0 - 1.00 m	Grey knobbly limestone.
1.00 - 1.05 m	Grey shale, GSC locality C-090407.
1.05 - 1.20 m	Limestone.
1.20 - 1.23 m	Grey shale, GSC locality C-090408.
1.23 - 1.82 m	Grey limestone.
1.82 - 1.90 m	Grey shaly limestone, GSC locality C-090409.
1.90 - 2.50 m	Grey argillaceous limestone.
2.50 - 2.65 m	Grey shale, GSC locality C-090410. Preservation of spores poor.
2.65 - 2.95 m	Grey shaly limestone.
2.95 - 3.10 m	Grey shale GSC locality C-090411.
3.10 - 4.10 m	Grey limestone.
4.10 - 4.70 m	Grey shale with thin limestone intercalations (0.01 m thick) GSC locality C-090412.
4.70 - 5.30 m	Grey shale with thin limestone intercalations (0.01 m thick) GSC locality C-090413.
5.30 - 8.30 m	Grey shaly limestone.
8.30 - 10.10 m	Grey shaly limestone, GSC locality C-090414.
10.10 - 13.10 m	Grey shaly limestone.
13.10 - 13.40 m	Grey calcareous shale, GSC locality C-090415.
13.40 - 13.70 m	Grey calcareous shale, GSC locality C-090416.

Possible fault in section?

13.70 - 17.35 m	Red-brown speckled sandstone and siltstone. Sample was taken from thin grey band in middle of unit. GSC locality C-090417.
17.35 m	Bottom of section.

Identifications: In samples C-090407 to C-090410, C-090414, C-090416 and C-090417, the preservation of spores is poor and no assemblages were recorded. In C-090411, C-090412, C-090413 and C-090415, preservation was relatively good and the following species were identified:

C-090411, *Retusotriletes incohatus, Schopfites claviger* and *Spelaeotriletes pretiosus* var. *windsorensis.*

C-090412, *Auroraspora macra, Convolutispora mellita, Crassispora trychera, Raistrickia magdalena, Rugospora minuta, Spelaeotriletes pretiosus* var. *bellii* and *Verrucosisporites morulatus.*

C-090413, *Acanthotriletes hacquebardii, Auroraspora macra, Convolutispora tessellata, Granulatisporites tuberculatus, Knoxisporites stephanephorus, Leiotriletes ornatus, Lycospora noctuina* var. *noctuina, Raistrickia clavata, Raistrickia magdalena, Retusotriletes incohatus, Schopfipollenites acadiensis* and *Schopfites claviger.*

C-090415, *Convolutispora mellita, Convolutispora tessellata, Crassispora trychera, Cristatisporites submarginatus, Knoxisporites probolos, Knoxisporites stephanephorus, Lycospora noctuina* var. *noctuina, Punctatisporites irrasus, Raistrickia magdalena, Retusotriletes incohatus, Rugospora corporata* var. *verrucosa, Rugospora minuta, Schopfipollenites acadiensis, Schopfites claviger* and *Spelaeotriletes pretiosus* var. *bellii.*

Remarks: The assemblages found in samples C-090413 and C-090415 of the Kennetcook Limestone may be assignable to the AT Zone, the affinities of those from C-090411 and C-090412 could not be determined.

c) Southwest of Moydart Point and northeast of Knoydart Point (see Figure 2); Antigonish County

The section of the Windsor Group sampled is shown as unit 20A on geological map sheet, Merigomish and Malignant Cove, 4-1970 E1/2. All of the samples were collected in the vicinity of the uppermost Windsor carbonate exposed at the locality dated by Mamet (1970) as zone 16 (Upper Windsor).

i) GSC D-1010-JS-32-72-4 and JS-32-72-5; latitude 45°42'5"N, longitude 62°13'6"W. Two samples from immediately below the uppermost Windsor carbonate.

GSC D-1010(A)-JS-32-72-4.

Identifications: The sample is dominated by *Colatisporites decorus*, *Crassispora trychera*, *Punctatisporites planus* and *Rugospora minuta*. Other species include *Auroraspora macra*, *Convolutispora tessellata*, *Convolutispora vermiformis*, *Crassispora trychera*, *Discernisporites micromanifestus*, *Granulatisporites tuberculatus*, *Leiotriletes ornatus*, *Lycospora noctuina* var. *noctuina*, *Punctatisporites irrasus*, *Punctatisporites planus*, *Raistrickia magdalena*, *Retusotriletes incohatus*, *Rugospora minuta*, *Rugospora polyptycha*, *Schopfipollenites acadiensis*, *Schopfites claviger*, *Spelaeotriletes pretiosus* var. *bellii*, *Spelaeotriletes pretiosus* var. *windsorensis*, *Verrucosisporites morulatus* and *Verrucosisporites nitidus*.

Concurrent range zone: AT Zone.

D-1010(B)-JS-32-72-5.

Identifications: The sample is dominated by *Crassispora trychera* and *Rugospora minuta*. Other species include *Auroraspora macra*, *Auroraspora solisortus*, *Chomotriletes multivittatus*, *Convolutispora tessellata*, *Convolutispora vermiformis*, *Discernisporites micromanifestus*, *Granulatisporites tuberculatus*, *Knoxisporites probolos*, *Leiotriletes ornatus*, *Micrhystridium*? sp. *Punctatisporites irrasus*, *Punctatisporites planus*, *Raistrickia magdalena*, *Retusotriletes incohatus*, *Schopfipollenites acadiensis*, *Schopfites claviger*, *Spelaeotriletes pretiosus* var. *windsorensis*, *Verrucosisporites nitidus* and *Verrucosisporites papulosus*.

Concurrent range zone: CT Zone.

ii) GSC locality C-097708.

This sample comes from a similar horizon to that described for GSC D-1010. The uppermost Windsor carbonate, which forms a small headland, is estimated to be 15 to 18 m thick. Sample C-097708 is taken from a 0.025 m black shale intercalation 0.3 m above the base of the carbonate on the west side of the headland.

Identifications: *Auroraspora solisortus*, *Biannulatisporites simplex*, *Calamospora parva*, *Colatisporites decorus*, *Convolutispora tessellata*, *Convolutispora vermiformis*, *Crassispora trychera*, *Granulatisporites tuberculatus*, *Leiosphaeridia*? *scotia*, *Lycospora noctuina* var. *noctuina*, *Neoraistrickia barssii*, *Punctatisporites planus*, *Retusotriletes incohatus*, *Rugospora minuta*, *Schopfites claviger*, *Schopfipollenites acadiensis*, *Spelaeotriletes pretiosus* var. *bellii*, *Spelaeotriletes pretiosus* var. *windsorensis* and *Verrucosisporites papulosus*. *Crassispora trychera* is common.

Concurrent range zone: AT Zone.

iii) GSC locality C-097709.

Beneath the carbonate described above for sample C-097708 is grey shale. Sample C-097709 is a grey shale collected 0.05 m below the base of the carbonate; 0.06 m below the base of the carbonate is a 0.075 m carbonate intercalation in the grey shale.

Identifications: *Auroraspora solisortus*, *Chomotriletes multivittatus*, *Convolutispora tessellata*, *Crassispora trychera*, *Granulatisporites tuberculatus*, *Lycospora noctuina* var. *noctuina*, *Punctatisporites planus*, *Rugospora minuta*, *Schopfites claviger*, *Schopfipollenites acadiensis* and *Verrucosisporites papulosus*. *Crassispora trychera* is common.

Concurrent range zone: EL Zone.

iv) GSC locality C-097710.

This sample was collected from the east side of the headland and is probably equivalent to the bed from which sample C-097709 was taken.

Identifications: *Anapiculatisporites fundiensis*, *Auroraspora solisortus*, *Calamospora parva*, *Convolutispora tessellata*, *Convolutispora vermiformis*, *Crassispora trychera*, *Grandispora uncata*, *Granulatisporites tuberculatus*, *Knoxisporites literatus*, *Knoxisporites triradiatus*, *Leiotriletes ornatus*, *Lycospora noctuina* var. *noctuina*, *Punctatisporites irrasus*, *Punctatisporites planus*, *Rugospora minuta*, *Rugospora polyptycha*, *Schopfites claviger*, *Schopfipollenites acadiensis*, *Spelaeotriletes pretiosus* var. *bellii*, *Spelaeotriletes pretiosus* var. *windsorensis*, *Spelaeotriletes tuberosus* and *Verrucosisporites papulosus*. *Crassispora trychera* is common.

Concurrent range zone: AT Zone.

d) East shore of Avon River Cheverie Formation type section, Cheverie (see Figure 2); Hants County

i) GSC locality C-078245, latitude 45°09'N, longitude 64°11'30"W. The type section was proposed, but not described in detail, by Bell (1929, p. 40). Sample C-078245 came from alternating shale and sandstone beds 3.0 m above very pale, grey grit, which together form a headland (see Figure 4). Assemblages from samples from this locality were described in detail by Playford (1963). Details of the assemblages have not been listed here, the sample being used specifically to study the abundant specimens of *Spelaeotriletes pretiosus*.

C) *Offshore Nova Scotia*

a) Cabot Strait (see Figure 2)

i) Petro-Canada et al. St. Paul P-91, latitude 46°10'57.88"N, longitude 60°13'36.83"W. Three samples of cuttings from beds assigned by lithostratigraphic criteria to the Windsor Group from 2195-2725 m contained *Crassispora trychera*, *Granulatisporites tuberculatus*, *Lycospora noctuina*, *Neoraistrickia* sp., *Punctatisporites irrasus*, *Raistrickia* sp., *Rugospora minuta*, *Schopfipollenites acadiensis*, *Schopfites claviger*, *Spelaeotriletes pretiosus* and *Verrucosisporites morulatus*. It was not possible to assign the assemblages reliably to either the NS or the AT Zone because of caving. However, useful information concerning thermal alteration was obtained. In the upper part of the interval studied, a Thermal Alteration Index of 4- was recorded, and in the lower part this increased to 4, with completely black spores (see Figure 11, and Thermal Alteration section).

QUEBEC (see Figure 3)

A) *Îles-de-la-Madeleine (Magdalen Islands). Havre aux Maisons Formation*

This formation, proposed by Sanschagrin (1964), is essentially equivalent to the Windsor Group of Nova Scotia, and was divided by him into two members consisting of the Cap Adèle Member (Lower Windsor) and Bassin-aux-Huîtres Member (Upper Windsor). Brisebois (1981) modified the subdivisions proposed by Sanschagrin, and suggested the name Cap au Diable Formation for those rocks in the sequence that are essentially volcanic, but he retained the Havre aux Maisons Formation for the sedimentary rocks of the Cap Adèle and Bassin-aux-Huîtres members.

a) Havre aux Maisons Island, Cap Adèle Member (sensu Sanschagrin, 1964).

Macrofossils collected by Sanschagrin from this member were considered by Bell to indicate a correlation with Subzone B of the Windsor Group (Bell, *in* Sanschagrin, 1964, p. 25).

i) GSC locality D-1481; 77-66-1; 700 m north of lighthouse on Cape Alright, topography map sheet Île aux Meules 11N/5, grid reference 927498 (see Figure 3B). Position approximately similar to fossil locality F2 of Sanschagrin (1964, p. 25).

The general lithotypes at this locality are reddish tuffaceous beds, but there is a 6 m intercalation of grey and green-grey laminated siltstone, and within this siltstone bed there is a thin, light grey sandstone bed. Sample 77-66-1 comes from a bed within the 6 m siltstone unit.

Identifications: *Auroraspora macra*, *Convolutispora labyrinthea*, *Convolutispora tessellata*, *Convolutispora vermiformis*, *Crassispora trychera*, *Cristatisporites submarginatus*, *Discernisporites micromanifestus*, *Leiotriletes ornatus*, *Punctatisporites irrasus*, *Punctatisporites planus*, *Raistrickia clavata*, *Retusotriletes incohatus*, *Rugospora minuta*, *Rugospora polyptycha*, *Schopfites claviger*, *Spelaeotriletes echinatus* and *Spelaeotriletes pretiosus* var. *bellii*, *Crassispora trychera*, *Punctatisporites irrasus*, *Punctatisporites planus* and *Rugospora minuta* are common.

Concurrent range zone: NS Zone.

ii) GSC localities C-097719 to C-097721 north of Cape Alright. These are discussed collectively because they contained poorly preserved assemblages and no age determinations were possible. They are included here because they give an indication of the Thermal Alteration Index (see Figures 3, 11 and Thermal Alteration section).

GSC locality C-097719. From a position approximately similar to D-1481, 77-66-1, but 400 m farther north. Here the section is badly slumped, but the lithotype is purplish brown siltstone with some greenish grey patches and some pale green bands. The sample was taken from a grey siltstone bed immediately below a thin carbonate bed.

GSC locality C-097720. From a position approximately similar to C-097719, but 100 m farther north. The sample comes from a thin, dark grey mudstone band within the purplish brown siltstone some 8 m south of the contact with the volcanic beds.

GSC locality C-097721. From a position approximately similar to C-097720, but only 6 m south of the contact with the volcanic beds.

iii) GSC localities C-090436 to C-090438, from Anse à Damase. This group of samples contained poorly preserved spores, but they were used in order to determine the Thermal Alteration Index (see Figure 3 and Thermal Alteration section).

GSC locality C-090436. From base of cliff 30 m east of locality F6 of Sanschagrin (1964) from a 0.05 m thick grey mudstone within reddish brown siltstone and gypsum.

GSC locality C-090437. From base of cliff, thin grey mudstone band at locality F6 of Sanschagrin.

GSC locality C-090438. From base of cliff, thin, dark grey mudstone approximately 350 m east of C-090437.

GSC locality C-090439. From base of cliff, thin, dark grey mudstone 450 m west of C-090438, and 20 m west of contact between reddish brown siltstone, mudstone and gypsum, and volcanic beds.

GSC locality C-090440. From base of cliff, thin, grey mudstone west of C-090439, and immediately east of the contact with the volcanic rocks.

GSC locality C-090441. From base of cliff, thin, grey mudstone at western contact between the volcanic rocks and the Windsor sediments. Sample taken immediately west of the contact.

b) Havre Aubert, Cap Adèle Member (**sensu** *Sanschagrin, 1964)*

i) GSC locality D-1477; 77-58-5. Anse à la Cabane, East of Cap du Sud-ouest, immediately west of new wharf shown on topography map sheet Havre Aubert 11N/4, grid reference 763297 (see Figure 3C). Sample from grey-black banded shale.

Identifications: *Convolutispora tessellata, Crassispora trychera, Knoxisporites probolos, Punctatisporites irrasus, Raistrickia clavata, Retusotriletes incohatus, Schopfites claviger* and *Spelaeotriletes pretiosus* var. *bellii.*

Concurrent range zone: NS Zone.

c) Île Boudreau, Bassin aux Huîtres Member (**sensu** *Sanschagrin, 1964)*

Macrofossils from this member were correlated with the Upper Windsor Group by Bell (in Sanschagrin, 1964, p. 35).

The section studied is on Île Boudreau (see Figure 3A), latitude 47°32'30"N, longitude 61°31'15"W, and was described by Sanschagrin (1964, Fig. 4, p. 33-34).

i) GSC locality C-090441. This sample comes from the upper half of bed N described by Sanschagrin (1964, p. 34) as pale and dark grey calcareous shale, and from which macrofossils had been collected and assigned to macrofaunal Subzone C by Bell (in Sanschagrin, 1964, p. 36).

Identifications: *Auroraspora solisortus, Convolutispora tessellata, Convolutispora vermiformis, Crassispora trychera, Cristatisporites submarginatus, Dictyotriletes odontolophos, Discernisporites micromanifestus, Granulatisporites tuberculatus, Knoxisporites literatus, Knoxisporites stephanephorus, Leiotriletes ornatus, Lycospora noctuina* var. *noctuina, Raistrickia baculosa, Raistrickia clavata, Raistrickia magdalena, Retusotriletes incohatus, Rugospora minuta, Schopfipollenites acadiensis, Schopfites claviger, Spelaeotriletes pretiosus* var. *bellii, Verrucosisporites morulatus, Verrucosisporites nitidus* and *Verrucosisporites papulosus.*

Remarks: Preservation of the specimens is not good and the identification of *Schopfipollenites acadiensis* is only tentative. Consequently, this bed can only provisionally be assigned to the AT Zone, although this would be consistent with the macrofaunal data.

ii) ROM-IDM-3-2. Approximate position 45 m above the contact of beds V and U of Sanschagrin (1964, Fig. 4). This part of the section is overturned, with the beds becoming younger toward the southwest. The sample comes from a 0.30 m siltstone unit approximately in the middle part of bed V.

Identifications: *Acanthotriletes hacquebardii, Anapiculatisporites fundiensis, Auroraspora macra, Auroraspora solisortus, Calamospora parva, Chomotriletes multivittatus, Convolutispora tessellata, Crassispora trychera, Dictyotriletes odontolophos, Discernisporites diaphanes, Discernisporites micromanifestus, Granulatisporites tuberculatus, Knoxisporites literatus, Lycospora noctuina* var. *noctuina, Punctatisporites irrasus, Pustulatisporites multicapitis, Retusotriletes incohatus, Rugospora corporata* var. *verrucosa, Rugospora minuta, Rugospora polyptycha, Schopfipollenites acadiensis, Schopfites claviger, Spelaeotriletes pretiosus* var. *bellii, Spelaeotriletes pretiosus* var. *windsorensis, Verrucosisporites morulatus, Verrucosisporites nitidus* and *Verrucosisporites papulosus.*

Concurrent range zone: AT Zone.

iii) ROM-IDM-3-3. Approximate stratigraphic position is 57 m above the contact of beds V and U (Sanschagrin, 1964, Fig. 4). The lithotypes are a light greenish grey siltstone (slightly calcareous) intercalated with light green shales. As pointed out for the previous sample (ROM-IDM-3-2), the beds at this interval are overturned.

Identifications: *Anapiculatisporites fundiensis, Auroraspora macra, Auroraspora solisortus, Convolutispora labyrinthea, Convolutispora vermiformis, Crassispora trychera, Cristatisporites submarginatus, Densosporites columbaris, Dictyotriletes odontolophos, Granulatisporites tuberculatus, Knoxisporites literatus, Knoxisporites probolos, Knoxisporites stephanephorus, Knoxisporites triradiatus, Leiotriletes inermis, Lycospora noctuina* var. *noctuina, Lycospora pusilla* "tendance B_2", *Neoraistrickia versiforma, Punctatisporites irrasus, Punctatisporites planus, Pustulatisporites multicapitis, Raistrickia clavata, Raistrickia magdalena, Retusotriletes incohatus, Rugospora minuta, Rugospora polyptycha, Schopfipollenites acadiensis, Schopfites claviger, Scutulum trisupplementum, Spelaeotriletes echinatus, Spelaeotriletes pretiosus* var. *bellii, Spelaeotriletes tuberosus* and *Verrucosisporites morulatus.*

Concurrent range zone: AT Zone.

iv) GSC locality D-1483, 77-56-15. From the younger part of bed V of Sanschagrin (1964, Fig. 4, p. 34), which he described as an argillaceous shale and grey, calcareous argillaceous shale with red bands. Certain of the grey beds contain pseudomorphs of salt crystals.

Identifications: *Convolutispora labyrinthea, Convolutispora tessellata, Convolutispora vermiformis, Crassispora trychera, Discernisporites micromanifestus, Grandispora spinosa, Ibrahimispores magnificus, Knoxisporites stephanephorus, Punctatisporites planus, Raistrickia baculosa, Raistrickia magdalena, Retusotriletes incohatus, Rugospora corporata* var. *verrucosa, Rugospora minuta, Schopfipollenites acadiensis, Schopfites claviger, Schulzospora bilunata* and *Spelaeotriletes pretiosus* var. *bellii.*

Concurrent range zone: SM Zone.

Remarks: The older part of bed V may be assigned to the AT Zone, whereas the younger part belongs to the SM Zone.

v) Samples were also taken from beds E and T of Sanschagrin, but although miospores were common, the preservation was very poor and no reliable assemblage lists were obtained.

NEW BRUNSWICK

a) Hopewell Cape Area (see Figure 4); Albert County

In a small bay 100 m southwest of Hopewell Cape, rocks of the Windsor Group outcrop; these have recently been called the Demoiselle Creek beds by McCutcheon (1981). They were previously part of the Hopewell Group of Norman (in McCutcheon, 1981), but locally, the Hopewell Group overlies the Demoiselle Creek beds according to the terminology of McCutcheon. Latitude 45°48'56"N, longitude 64°34'40"W; topographic map sheet Hillsborough 21H/15E, grid reference 775746.

i) GSC locality D-1471, 77-44-6 (see Figure 5). From approximately 45 m below the base of a conglomerate in the Hopewell Group, which overlies the section containing carbonate intercalations (Demoiselle Creek beds). It comes from a 0.9 m thick yellow-grey mottled siltstone and sandstone. Above this bed is a 0.9 m calcarenite, which contains large stromatolite mounds, and below it is a 0.6 m thick calcarenite.

Identifications: *Convolutispora labyrinthea*, *Convolutispora mellita*, *Crassispora trychera*, *Punctatisporites planus* and *Rugospora minuta*. Preservation is poor. Present also was a single specimen of a scolecodont.

Concurrent range zone: NS Zone.

ii) GSC locality D-1471, 77-44-4. From immediately below the 0.6 m calcarenite described above for sample 77-44-6. Sample 77-44-4 comes from a 1.8 m mottled siltstone and sandstone, which is red-green and grey; this bed is underlain by 1.2 m of red conglomerate.

Identifications: *Convolutispora tessellata*, *Crassispora trychera*, *Leiotriletes inermis*, *Rugospora minuta*, *Verrucosisporites acadiensis*, *Verrucosisporites morulatus*, and *Verrucosisporites nitidus*.

Concurrent range zone: NS Zone.

iii) GSC locality C-090434. Collected 0.3 m below the base of the conglomerate mentioned for GSC locality D-1971. The sample is from a thin (0.02 m) shaly intercalation.

Identifications: *Auroraspora macra*, *Crassispora trychera*, *Discernisporites micromanifestus*, *Leiotriletes inermis*, *Lycospora noctuina* var. *noctuina*, *Lycospora pusilla* "tendance B_2", *Punctatisporites irrasus*, *Punctatisporites planus*, *Retusotriletes incohatus*, *Rugospora minuta*, *Schopfites claviger*, *Vallatisporites ciliaris*, *Verrucosisporites morulatus* and *Verrucosisporites papulosus*.

Concurrent range zone: NS Zone.

iv) GSC locality D-1971. From a thin mudstone unit 3.1 m above the uppermost carbonate bed in the section and stratigraphically above the Demoiselle Creek beds (see McCutcheon, 1981, Fig. A8-1, East section).

Identifications: *Auroraspora macra*, *Convolutispora labyrinthea*, *Convolutispora tessellata*, *Crassispora trychera*, *Discernisporites micromanifestus*, *Punctatisporites irrasus*, *Retusotriletes incohatus*, *Rugospora minuta*, *Spelaeotriletes pretiosus* var. *bellii* and *Verrucosisporites papulosus*.

Concurrent range zone: NS Zone.

Conclusions: Fossiliferous carbonates of the Windsor Group in the section at Hopewell Cape were tentatively assigned to macrofaunal Subzone C by Bell (in Gussow, 1953, p. 1747), because of the presence of *Paleocrisidia* (*Nodosinsella*), although this genus is now known to occur also in macrofaunal Subzone B (see Moore and Ryan, 1976, Figure 3). Samples from the section containing carbonate beds and from beds overlying this unit contain assemblages typical of the NS Zone. Thus, the palynological data do not support the suggestion of Bell that Upper Windsor rocks are present at this locality.

b) Borehole Millstream No. 1 (see Figure 4), Kings County

Borehole Millstream No. 1, (located at latitude 45°42'N, longitude 65°38'W, Studholm Parish, Kings County), drilled under sponsorship of the Department of Regional Economic Expansion, project no. 9317, in order to investigate the economic potential of potash deposits in the Kings County area. Massive evaporite deposits were not intersected in this well but possibly occur below 922.63 m.

The sample intervals given below are in metres and the depth is measured from the top of the borehole (GSC locality C-090401).

Depth 918.06 m. The sample is from 0.05 m of grey, hard siltstone within a brown siltstone unit.

Identifications: *Calamospora parva*, *Crassispora trychera*, *Punctatisporites irrasus*, *Retusotriletes incohatus*, *Rugospora minuta* and *Schopfites claviger*. *Crassispora trychera* is common.

Depth 919.58 m. The sample is grey siltstone and/or mudstone.

Identifications: *Auroraspora macra*, *Crassispora trychera*, *Punctatisporites planus*, *Retusotriletes incohatus*, *Rugospora minuta* and *Schopfites claviger*.

Depth 919.89 m. The sample is grey siltstone and/or mudstone.

Identifications: *Auroraspora macra*, *Crassispora trychera*, *Punctatisporites irrasus*, *Retusotriletes incohatus* and *Rugospora minuta*.

Depth 920.50 m. The sample is grey siltstone and/or mudstone.

Identifications: *Crassispora trychera*, *Punctatisporites irrasus* and *Punctatisporites minutus*.

Depth 920.80 m. The sample is grey siltstone and/or mudstone.

Identifications: *Auroraspora macra*, *Crassispora trychera*, *Punctatisporites irrasus*, *Retusotriletes incohatus* and *Schopfites claviger*. *Crassispora trychera* is common.

Depth 921.71 m. The sample is grey siltstone and/or mudstone.

Identifications: *Crassispora trychera*, *Punctatisporites planus* and *Retusotriletes incohatus*.

Depth 922.63 m. The sample is grey siltstone and/or mudstone.

Identifications: *Crassispora trychera* and *Rugospora minuta*.

Remarks: The assemblages listed above are tentatively assigned to the NS Zone.

S.W. NEWFOUNDLAND (see Figure 6)

A) ***Ship Cove Formation, Codroy Group***

The name Ship Cove limestone was proposed by Bell (1948) and the formational status was suggested by Knight (1983).

a) Codroy Island (see Figure 6)

A single composite sample (C-097738, latitude 47°52'30"N, longitude 59°23'45"W) collected from the 8.0 m of exposed limestone on the southeastern tip of Codroy Island proved to be barren. This locality and others, believed to be lateral equivalents of the Ship Cove Formation, were sampled for conodonts by von Bitter and Plint-Geberl (1982, Figures 2-8).

They assigned the assemblages to the *Diplognathodus* Zone, which they correlated with macrofaunal Subzone A of Bell (1929). The conodont residues from these other localities were investigated by the author for palynomorphs.

b) Fischells Brook (see Figure 6); St. Georges Bay

At Fischells Brook, the contact between the Ship Cove Formation and the conglomerate and sandstone of the Anguille Group is exposed. Details concerning sample localities and stratigraphic positions are given in von Bitter and Plint-Geberl (1982, Fig. 3, locality 4; Fig. 6; Appendix, locality 4).

i) ROM-Shp Cv-4-1. From the basal 1.14 m of the Ship Cove Formation.

Identifications: *Crassispora trychera*, *Lycospora noctuina* var. *noctuina* and *Punctatisporites planus*.

Concurrent range zone: NS Zone.

ii) ROM-Shp Cv-Sp-1. From the basal 0.10-0.13 m of the Ship Cove Formation.

Identifications: *Convolutispora mellita*, *Convolutisporites tessellata*, *Crassispora trychera*, *Lycospora noctuina* var. *noctuina*, *Punctatisporites planus*, *Retusotriletes incohatus*, *Schopfites claviger*, *Spelaeotriletes echinatus*, *Vallatisporites ciliaris*, *Verrucosisporites nitidus* and *Verrucosisporites papulosus*.

Concurrent range zone: NS Zone.

iii) ROM-Shp Cv-Sp-2. From 0.61-1.19 m above the base of the Ship Cove Formation.

Identifications: *Convolutisporites mellita*, *Crassispora trychera*, *Punctatisporites minutus*, *Rugospora minuta*, *Schopfites claviger*, *Spelaeotriletes echinatus*, *Vallatisporites ciliaris*, *Verrucosisporites nitidus* and *Verrucosisporites papulosus*.

Concurrent range zone: NS Zone.

iv) ROM-Shp Cv-4-2. Approximately 3.66 m above the base of the Ship Cove Formation, sample from interval of 0.60-0.91 m.

Identifications: *Crassispora trychera*, *Discernisporites micromanifestus*, *Punctatisporites irrasus*, *Punctatisporites planus*, *Retusotriletes incohatus*, *Schopfites claviger*, *Spelaeotriletes echinatus*, *Vallatisporites ciliaris*, *Verrucosisporites nitidus* and *Verrucosisporites papulosus*.

Concurrent range zone: NS Zone.

v) ROM-Shp Cv-4-3. Uppermost 0.91-1.22 m of the exposure of the Ship Cove Formation.

Identifications: *Acanthotriletes hacquebardii*, *Auroraspora macra*, *Auroraspora solisortus*, *Colatisporites* *decorus*, *Convolutispora labyrinthea*, *Convolutispora tessellata*, *Crassispora trychera*, *Densosporites columbaris*, *Discernisporites micromanifestus*, *Granulatisporites tuberculatus*, *Leiotriletes ornatus*, *Lycospora noctuina* var. *noctuina*, *Lycospora pusilla* "tendance B_2", *Microreticulatisporites hacquebardii*, *Punctatisporites irrasus*, *Punctatisporites minutus*, *Raistrickia clavata*, *Rugospora minuta*, *Schopfites claviger*, *Spelaeotriletes echinatus*, *Vallatisporites ciliaris*, *Verrucosisporites morulatus*, *Verrucosisporites nitidus* and *Verrucosisporites papulosus*.

Concurrent range zone: NS Zone.

Remarks: Quantitative data for this sample are shown in Figure 10.

c) Aguathuna (see Figure 6); Port au Port Peninsula

The samples in this locality were taken from a 5.4 to 6.0 m, brachiopod-rich Carboniferous limestone, which fills in erosion surfaces and fissures of the Ordovician limestone of the Table Head Formation (von Bitter and Plint-Geberl, 1982). Bell (1948, p. 34) suggested that this Carboniferous limestone may be correlated with the Upper Windsor of Nova Scotia and that it may be as young as Subzone E. However, the work of von Bitter and Plint-Geberl (1982) does not support this suggestion and they assign this unit to the *Diplognathodus* Zone, which they correlated with the macrofaunal Subzone A of Bell (1929). Kirkham (pers. comm., 1985) questioned correlation of these beds with the basal Windsor (Subzone A), in spite of the conodont data. In his view, the beds have been redeposited and are different lithologically from typical Ship Cove Formation beds. He further pointed out that brachiopods collected from the unit were identified by Gordon and Dutro (1984) as probably of Windsor Subzone B age, although specimens from a lithologically similar unit at nearby Lead Cove contained a fauna that was probably from Subzone E.

Details concerning sample localities and stratigraphic positions are given in von Bitter and Plint-Geberl (1982, Fig. 5, locality 2; Fig. 6; Appendix, locality 2). The stratigraphic positions given below are from von Bitter (pers. comm., 1983).

i) ROM-Agu-1-1. From the base of the Carboniferous limestone.

Identifications: *Auroraspora macra*, *Convolutispora labyrinthea*, *Crassispora trychera*, *Cristatisporites submarginatus*, *Lycospora noctuina* var. *noctuina*, *Microreticulatisporites hacquebardii*, *Punctatisporites planus*, *Rugospora minuta*, *Rugospora polyptycha*, *Schopfites claviger*, *Vallatisporites ciliaris* and *Verrucosisporites papulosus*.

Concurrent range zone: NS Zone.

ii) ROM-Agu-1-2. From the apparent top of the Carboniferous limestone.

Identifications: *Crassispora trychera*, *Leiotriletes ornatus*, *Microreticulatisporites hacquebardii*, *Punctatisporites planus*, *Raistrickia clavata*, *Rugospora minuta*, *Verrucosisporites nitidus* and *Verrucosisporites papulosus*.

Concurrent range zone: NS Zone.

Remarks: As only one spore zone may be recognized in the Lower Windsor (NS Zone) the palynological data are insufficient to resolve the problem of whether these beds should be assigned to Subzone A or B. However, these data do confirm an age consistent with the Lower Windsor, in spite of the fact that the rocks containing the fossils may have been redeposited.

d) Boswarlos (see Figure 6); Port au Port Peninsula

Details concerning sample localities and stratigraphic positions within the Ship Cove Limestone are given in von Bitter and Plint-Geberl (1982, Fig. 5, locality 1; Fig. 6; Appendix, locality 1). They assigned these beds to the Ship Cove Formation, but Kirkham (pers. comm., 1985) suggested that the Windsor rocks have been resedimented, like the beds at Aguathuna, described above; they are unlike typical Ship Cove Formation rocks, as they consist of graded and slumped beds.

i) ROM-Bos-1-5. 1.32 m of limestone at top of section; basal 0.6 m massive and irregularly weathered, containing fossil fragments and pellets; above this the lithotypes are similar except that weathering makes the rocks more friable.

Identifications: *Crassispora trychera*, *Discernisporites micromanifestus*, *Lycospora noctuina* var. *noctuina*, *Lycospora pusilla* "tendance B_2", *Punctatisporites irrasus*, *Punctatisporites minutus*, *Punctatisporites planus*, *Retusotriletes incohatus*, *Rugospora minuta*, *Schopfites claviger* and *Verrucosisporites papulosus*.

Concurrent range zone: NS Zone.

ii) ROM-Bos-1-3. 0.27 m above the base of the section is the base of a 0.76 m thin bedded limestone which alternates with light grey shaly interbeds.

Identifications: *Auroraspora macra*, *Convolutispora mellita*, *Convolutispora tessellata*, *Crassispora trychera*, *Leiotriletes inermis*, *Lycospora noctuina* var. *noctuina*, *Punctatisporites minutus*, *Punctatisporites planus*, *Retusotriletes incohatus*, *Rugospora polyptycha*, *Schopfites claviger*, *Spelaeotriletes echinatus* and *Verrucosisporites papulosus*.

Concurrent range zone: NS Zone.

iii) ROM-Bos-1-2. 0.08 m above the base of the section is 0.18 m of black shale. Quantitative data for this sample are shown in Figure 10.

Identifications: *Anapiculatisporites fundiensis, Auroraspora macra, Colatisporites decorus, Convolutispora labyrinthea, Convolutispora mellita, Convolutispora tessellata, Crassispora trychera, Cristatisporites submarginatus, Discernisporites micromanifestus, Knoxisporites literatus, Microreticulatisporites hacquebardii, Punctatisporites irrasus, Punctatisporites planus, Raistrickia clavata, Retusotriletes incohatus, Rugospora minuta, Schopfites claviger, Spelaeotriletes echinatus, Spelaeotriletes pretiosus* var. *bellii, Vallatisporites ciliaris, Verrucosisporites morulatus, Verrucosisporites nitidus* and *Verrucosisporites papulosus.*

Concurrent range zone: NS Zone.

iv) ROM-Bos-1-1. 0.08 m of thin bedded, medium grey limestone at the base of the section.

Identifications: *Anapiculatisporites fundiensis, Crassispora trychera, Leiotriletes ornatus, Punctatisporites planus, Rugospora minuta, Schopfites claviger, Vallatisporites ciliaris, Verrucosisporites papulosus* and *Verrucosisporites nitidus.*

Concurrent range zone: NS Zone.

Remarks: The assignment of these assemblages to the Lower Windsor Group is not inconsistent with the correlation by von Bitter and Plint-Geberl (1982), although, as outlined above for the Aguathuna samples, it is not possible from the palynological data to confirm a Subzone A age, or to disprove any redeposition which may have occurred.

e) Romaines Brook (see Figure 6); near Port au Port Peninsula

Details concerning sample localities and stratigraphic positions are given in von Bitter and Plint-Geberl (1982, Fig. 5, locality 3; Fig. 6; Appendix, locality 3).

i) ROM-Rom-1-2. At the base of the section is 0.13 m of medium bedded, fine grained, grey and non-laminated limestone.

Identifications: *Convolutisporites labyrinthea, Crassispora trychera, Retusotriletes incohatus, Rugospora minuta, Schopfites claviger* and *Vallatisporites ciliaris.*

Concurrent range zone: NS Zone.

ii) ROM-Rom-1-3. 1.22 m above the base of the section is 0.46 m of grey, medium to thick bedded limestone.

Identifications: *Auroraspora macra, Discernisporites micromanifestus, Knoxisporites literatus, Leiotriletes ornatus, Lycospora pusilla* "tendance B_2", *Punctatisporites irrasus, Punctatisporites minutus, Raistrickia clavata, Retusotriletes incohatus, Rugospora minuta, Schopfites claviger, Vallatisporites ciliaris* and *Verrucosisporites papulosus. Crassispora trychera* is dominant.

Concurrent range zone: NS Zone.

B) Codroy Road Formation, Codroy Group

The name was proposed by Knight (1983) for beds described by Hayes and Johnson (1938) as the Codroy shale. The name "Woodville formation" was previously used informally by Brown and Knight (1977).

a) Cliff section between Codroy and Woodville (see Figure 6)

This section was described by Bell (1948, p. 18, latitude 47°52'30"N, longitude 59°23'W).

Four samples were taken from this section and, although preservation of spores is poor, the samples provide useful data concerning the Thermal Alteration Index, which is estimated to be 3 to 3+.

C-097731 was taken from a 1.0 m thick grey shale unit within a gypsum bed, which is possibly equivalent to, or slightly lower than, Bed 3 (Bell 1948, p. 18).

C-097732 was from a 2.0 m thick dark grey shale within the gypsum of Bed 3 (Bell 1948, p. 18).

C-097733 was from a grey siltstone unit in Bed 4 (Bell 1948, p. 18), 6.0 m above the top of Bed 3.

C-097734 was from a dark grey argillaceous bed from the upper part of Bed 4 (Bell, 1948, p. 18).

b) Cliff section approximately 1 km south of Woodville village (see Figure 6)

Samples were collected from the section described by Bell (1948, p. 18) latitude 47°51'30"N, longitude 59°22'W.

Three samples were collected from this locality and, like those described above, were poorly preserved. However, the samples provide useful data concerning the Thermal Alteration Index, which is estimated to be 3 to 3+. Identifiable palynomorphs occur in C-097737.

C-097735 was from Bed 20 of Bell (1948, p. 17), and was collected from gypsiferous shale 1.0 m below the base of Bed 21 (Bell 1948, p. 17).

C-097736 was from a 1.0 m thick dark grey shale bed in the middle of Bed 25 (Bell 1948, p. 17).

C-097737 was from a 1.5 m thick dark grey shale bed within Bed 36 (Bell 1948, p. 17).

Identifications: *Crassispora trychera*, *Discernisporites micromanifestus*, *Lycospora noctuina* var. *noctuina*, *Rugospora minuta*, *Rugospora polyptycha*, *Schopfites claviger* and *Spelaeotriletes pretiosus* var. *windsorensis*.

Concurrent range zone: N.S. Zone.

C) Robinsons River Formation, Mollichignick Member, Codroy Group

The formation and member names were proposed by Knight (1983).

a) Codroy Valley

GSC locality C-090420 to C-090425, latitude 47°53'30"N, longitude 59°06'30"W. This locality is situated on the south bank of the Codroy River, 1 km west-southwest of the confluence of the Mollichignick Brook and the Codroy River, and immediately south of the western tip of an island 0.25 km long situated in the Codroy River (see Figure 6). This section was locality F2 of Utting (1966), who reported finding gastropods and pelecypods in dark grey calcareous lutite, which contained thin limestone beds generally less than 0.15 m thick. The fauna was sent to W.A. Bell, who identified the material (pers. comm., 1964) as *Murchisonia gypsea* Dawson, *Sanguinolites parvus*? Bell and *Sanguinolites striatogranulatus* Hind. Bell considered that the presence of these fossils indicated a Windsor macrofaunal Subzone B age rather than Subzone C, but further collecting of bivalves by McGlynn (in Knight, 1983, p. 208) suggests a Subzone D age.

Palynological information concerning a sample from the Mollichignick Member collected by I. Knight was obtained by the author and listed in Knight (1983, p. 206-208). The sample was collected immediately beneath the beds containing a shelly fauna recorded by Utting (1966), near Limestone Brook and Gillans Island on the Grand Codroy River. The miospore assemblage contains *Auroraspora macra*, *Auroraspora solisortus*, *Crassispora trychera*, *Dictyotriletes odontolophos*, *Discernisporites micromanifestus*, *Granulatisporites tuberculatus*, *Knoxisporites probolos*, *Knoxisporites stephanephorus*, *Knoxisporites triradiatus*, *Lycospora noctuina* var. *noctuina*, *Punctatisporites irrasus*, *Punctatisporites planus*, *Raistrickia magdalena*, *Retusotriletes incohatus*, *Rugospora minuta*, *Schopfipollenites acadiensis*, *Secarisporites remotus*, *Spelaeotriletes pretiosus* var. *windsorensis*, *Verrucosisporites morulatus* and *Verrucosisporites papulosus*.

Concurrent range zone: AT Zone.

The slight difference between the assemblage list given by Knight (1983) and that listed here is due to the fact that since the original identifications were made in 1978, the systematic description of new species has been completed. The updated list includes some of these newly described forms and a few other species that were not seen in the original preparation.

Additional palynological samples were collected by the author from the locality described above. The section is approximately 40.5 m thick and the stratigraphic position of the samples is shown below:

Top of section

0 - 12.19 m	Purple siltstone with thin, dolomitic beds.
12.19 - 14.02 m	Parallel bedded, alternating dolomite and grey siltstone.
14.02 - 14.78 m	Shale bed with some sandy intercalations; near the top pelecypods and gastropods occur (GSC locality C-090420).
14.78 - 17.83 m	Frequent alternation of black shale with grey dolomitic sandstone; pelecypods occur. (GSC locality C-090421, represents composite sample from shale units).
17.83 - 23.93 m	Purplish siltstone with intercalations of dolomite.
23.93 - 28.50 m	Black shale with intercalations of dolomite.
28.50 - 28.65 m	Black shale (GSC locality C-090422).
28.65 - 28.95 m	Dolomitic sandstone.
28.95 - 29.10 m	Black shale (GSC locality C-090423).
29.10 - 29.32 m	Dolomite.
29.32 - 29.77 m	Shale bed with thin intercalations (0.06 m) of nodular calcareous units (GSC locality C-090424).
29.77 - 30.15 m	Light grey dolomitic sandstone.
30.15 - 30.45 m	Alternation of fine micaceous light grey sandstone with four black shale beds approximately 0.05 m thick (GSC locality C-090425).
30.45 - 32.89 m	Grey calcareous sandstone containing grey siltstone pebbles (intraformational?) near base. Fining upwards, almost parallel bedded.
32.89 - 40.51 m	Purple-brown siltstone, and sandstone speckled green and grey in places.

Base of section.

i) GSC locality C-090420 (14.02-14.78 m)

Identifications: *Auroraspora macra*, *Calamospora parva*, *Crassispora trychera*, *Cristatisporites submarginatus*, *Discernisporites submarginatus*, *Knoxisporites triradiatus*, *Leiotriletes inermis*, *Punctatisporites irrasus*, *Punctatisporites planus*, *Raistrickia magdalena*, *Rugospora minuta*, *Rugospora polyptycha*, *Schopfipollenites acadiensis*, *Spelaeotriletes echinatus*, *Spelaeotriletes pretiosus* var. *windsorensis* and *Spelaeotriletes tuberosus*.

Concurrent range zone: AT Zone.

ii) GSC locality C-090421 (14.78-17.83 m)

Identifications: *Calamospora parva*, *Convolutispora labyrinthea*, *Crassispora trychera*, *Leiotriletes* sp., *Lycospora noctuina* var. *noctuina*, *Punctatisporites irrasus*, *Punctatisporites planus*, *Rugospora minuta*, *Schopfites claviger*, *Spelaeotriletes echinatus* and *Spelaeotriletes pretiosus* var. *windsorensis*.

Concurrent range zone: NS? Zone.

iii) GSC locality C-090422 (28.50-28.65 m)

Identifications: *Crassispora trychera*, *Discernisporites micromanifestus*, *Elektoriskos* sp. A., *Granulatisporites tuberculatus*, *Knoxisporites stephanephorus*, *Leiotriletes inermis*, *Lycospora noctuina* var. *noctuina*, *Punctatisporites planus*, *Rugospora minuta*, *Rugospora polyptycha*, *Spelaeotriletes echinatus*, *Spelaeotriletes pretiosus* var. *windsorensis* and *Verrucosisporites papulosus*.

Concurrent range zone: NS? Zone.

iv) GSC locality C-090423 (28.95-29.10 m)

Identifications: *Convolutispora vermiformis*, *Crassispora trychera*, *Dictyotriletes odontolophos*, *Elektoriskos* sp. A., *Granulatisporites tuberculatus*, *Lycospora noctuina* var. *noctuina*, *Punctatisporites irrasus*, *Punctatisporites planus*, *Rugospora minuta*, *Spelaeotriletes echinatus*, *Spelaeotriletes pretiosus* var. *bellii* and *Verrucosisporites papulosus*.

Concurrent range zone: NS? Zone.

v) GSC locality C-090424 (29.32-29.77 m)

Identifications: *Anapiculatisporites fundiensis*, *Convolutispora labyrinthea*, *Convolutispora tessellata*, *Crassispora trychera*, *Dictyotriletes submarginatus*, *Granulatisporites tuberculatus*, *Knoxisporites probolos*, *Knoxisporites stephanephorus*, *Lycospora pusilla*, *Lycospora noctuina* var. *noctuina*, *Neoraistrickia versiforma*, *Punctatisporites irrasus*, *Punctatisporites planus*, *Raistrickia magdalena*, *Rugospora minuta*, *Rugospora polyptycha*, *Scutulum trisupplementum*, *Spelaeotriletes echinatus*, *Spelaeotriletes pretiosus* var. *bellii*, *Spelaeotriletes pretiosus* var. *windsorensis* and *Verrucosisporites papulosus*.

Concurrent range zone: NS? Zone.

vi) GSC locality C-090425 (30.15-30.45 m)

Identifications: *Anapiculatisporites fundiensis*, *Convolutispora labyrinthea*, *Convolutispora tessellata*, *Crassispora trychera*, *Dictyotriletes submarginatus*, *Dictyotriletes odontolophos*, *Granulatisporites tuberculatus*, *Knoxisporites stephanephorus*, *Leiotriletes ornatus*, *Lycospora noctuina* var. *noctuina*, *Punctatisporites irrasus*, *Punctatisporites planus*, *Pustulatisporites multicapitis*, *Raistrickia magdalena*, *Rugospora minuta*, *Rugospora polyptycha*, *Schopfites claviger*, *Spelaeotriletes echinatus*, *Spelaeotriletes pretiosus* var. *bellii*, *Spelaeotriletes tuberosus*, *Verrucosisporites morulatus*, *Verrucosisporites nitidus* and *Verrucosisporites papulosus*.

Concurrent range zone: NS? Zone.

Conclusions: The assemblages from all the samples are generally similar, but the presence of *Knoxisporites triradiatus* and *Schopfipollenites acadiensis* in the uppermost sample (C-090420) indicates that the upper part of the section may be assigned to the AT Zone. Species diagnostic of the AT Zone are lacking in the remainder of the samples, which have thus tentatively been assigned to the NS Zone. An interesting feature of all of the samples is the presence of *Spelaeotriletes echinatus*. This species is rare and only occasionally found in samples from other parts of Atlantic Canada.

D) Undifferentiated Lower Codroy Group

a) Heatherton (see Figure 6), St. George's Bay

The section on the shore at Heatherton and in the lower part of Rattling Brook was described by Bell (1948, p. 31). This section was sampled by von Bitter and Plint-Geberl, who assigned the beds to the *Cavusgnathus* Zone (1982, Fig. 3, locality 6; Fig. 5; Appendix, locality 6), this conodont zone was correlated with the upper part of the macrofaunal Subzone B of Bell (1929).

i) ROM-Heath-2-9 from 0.20 m of earthy cream weathering limestone 22.5 m below the base of the Heatherton Limestone of Bell (1949, p. 31) contained a rich assemblage of spores, which are listed below:

Identifications: *Convolutispora labyrinthea*, *Crassispora trychera*, *Cristatisporites submarginatus*, *Knoxisporites stephanephorus*, *Leiotriletes inermis*, *Lycospora noctuina* var. *noctuina*, *Microreticulatisporites hacquebardii*, *Punctatisporites irrasus*, *Punctatisporites planus*, *Raistrickia clavata*, *Rugospora minuta*, *Vallatisporites ciliaris*, *Verrucosisporites morulatus*, *Verrucosisporites nitidus* and *Verrucosisporites papulosus*. *Crassispora trychera* is dominant.

Concurrent range zone: NS Zone.

E) Woody Cape Formation (name proposed by Knight, 1983), Codroy Group

The beds sampled were from the coastal sections north and south of Woody Cape (see Figure 6), which were measured by Bell (1948). He named them the Woody Cove beds and correlated them with macrofaunal Subzones C, D and E of the Windsor Group of Nova Scotia.

a) Section north of Woody Cape (see Figure 6)

Latitude 47°51'30"N, longitude 59°22'W.

i) GSC locality C-090426. 6.10 m dark grey calcareous siltstone, with alternations of thin, greenish grey, fine grained sandstone (equivalent to Bed 54 of Bell, 1948, p. 16).

Identifications: *Crassispora trychera*, *Punctatisporites irrasus*, *Rugospora minuta*, *Schopfites claviger* and *Spelaeotriletes pretiosus* var. *bellii*.

ii) GSC locality C-090427. 20.0 m dark grey shale, mudstone and siltstone with calcareous bands (equivalent to Bed 56 of Bell, 1948, p. 16).

Identifications: *Convolutispora tessellata*, *Crassispora trychera*, *Schopfipollenites acadiensis* and *Schopfites claviger*

iii) GSC locality C-090428. 27.0 m greenish grey shale and arenaceous siltstone, dark grey argillaceous shale; thin gypsum bands (equivalent to Bed 60 of Bell, 1948, p. 16).

Identifications: *Discernisporites micromanifestus*, *Granulatisporites tuberculatus*, *Retusotriletes incohatus* and *Rugospora minuta*.

iv) GSC locality C-090429. 3.35 m dark grey arenaceous shale (equivalent to Bed 105 of Bell, 1948, p. 15).

Identifications: *Crassispora trychera*, *Lycospora noctuina* var. *noctuina*, *Knoxisporites probolos*, *Punctatisporites irrasus*, *Rugospora minuta*, *Schopfites claviger*, *Schopfipollenites acadiensis* and *Spelaeotriletes pretiosus* var. *bellii*.

v) GSC locality C-090430. Massive sandstone with some shaly intercalations 100 m south-southwest of sample C-090429. 3 m above sample C-090430, Utting (1966) recorded fossil tetrapod trackways on an exposed bedding plane at the cliffs. But in 1977, the large block containing those fossils could not be relocated, and had presumably fallen into the sea.

Identifications: *Anapiculatisporites fundiensis*, *Crassispora trychera*, *Rugospora corporata* var. *verrucosa*, *Rugospora minuta* and *Spelaeotriletes pretiosus* var. *bellii*.

Remarks: GSC C-090427 to C-090430 may be assigned to the AT Zone, the age of GSC locality C-090426 was not determined.

b) Section south of Woody Cape in Capelin Cove (see Figure 6)

This section, according to Knight (pers. comm., 1978) is inverted. Therefore the basal beds are in the south part of the section and they become younger northward (latitude 47°50'30"N, longitude 59°22'W).

i) GSC locality C-090431. 3 m thick dark grey to black shale bed; 44 m from the base of the section, 171 m from the top of the section.

Identifications: *Crassispora trychera*, *Discernisporites micromanifestus*, *Knoxisporites triradiatus*, *Lycospora noctuina* var. *noctuina*, *Punctatisporites planus*, *Rugospora minuta*, *Schopfipollenites acadiensis* and *Spelaeotriletes pretiosus* var. *bellii*.

Concurrent range zone: AT Zone.

ii) GSC locality C-090432 1 m thick black shale overlying redbed. 60 m from the base of the section, 155 m from the top of the section.

Identifications: *Chomotriletes multivittatus*, *Crassispora trychera*, *Retusotriletes incohatus* and *Schopfipollenites acadiensis*.

Concurrent range zone: AT Zone.

F) Searston Formation (formation status proposed by Knight, 1983), Barachois Group

The beds sampled were from the coastal sections north and south of the Grand Codroy River.

a) North of the Grand Codroy River

i) Capelin Cove. GSC locality C-097717. Approximately 900 m east-northeast of Stormy Point, latitude 47°50'25"N, longitude 59°22'15"W (see Figure 6). Green-grey and red sandstone, conglomerate, and red, green, blue-grey, grey, and black siltstone and mudstone.

Identifications: *Auroraspora macra*, *Crassispora trychera*, *Discernisporites micromanifestus*, *Granulatisporites granulatus*, *Knoxisporites triradiatus*, *Lycospora noctuina* var. *noctuina*, *Potonieisporites elegans* (incomplete specimen), *Retusotriletes incohatus*, *Schopfites claviger* and *Schulzospora bilunata*.

Remarks: The presence of *Potonieisporites elegans* suggests an age younger than that of the SM Zone.

ii) GSC locality C-090450. Approximately 850 m east-northeast of Stormy Point, latitude 47°50'25"N, longitude 59°22'15"W (see Figure 6). The rocks consist of grey, crossbedded medium grained sandstone with many thin, grey shale intercalations rich in carbonaceous material. Dark grey carbonaceous shale pebbles are common at the base of the sandstone units and represent intraformational deposits. Sample C-090450 comes from a 0.15-0.30 m intercalation of dark grey shale. The preservation of fossils is poor.

Identifications: *Chomotriletes multivittatus*, *Crassispora trychera*, *Dictyotriletes odontolophos*, *Knoxisporites stephanephorus*, *Knoxisporites triradiatus*, *Leiotriletes inermis*, *Lycospora noctuina* var. *noctuina*, *Lycospora pusilla* "tendance B_2", *Neoraistrickia versiforma*, *Raistrickia magdalena*, *Rugospora minuta*, *Rugospora polyptycha*, *Schopfipollenites acadiensis*, *Schopfites claviger*, *Spelaeotriletes pretiosus* var. *bellii*, *Spelaeotriletes pretiosus* var. *windsorensis* and *Verrucosisporites papulosus*.

Remarks: Quantitatively, this assemblage resembles those in the SM Zone, although stratigraphically diagnostic species are lacking.

b) *South of the Grand Codroy River, south of Kennedy Point*

i) GSC locality C-097718. Approximately 450 m south of Kennedy Point, latitude 47°49'08"N, longitude 59°19'45"W (see Figure 6). The rocks are dark grey shale and siltstone alternating with grey, pebbly sandstone, grey, fine grained sandstone and purple-grey, fine grained sandstone.

Identifications: *Knoxisporites stephanephorus*, *Lycospora noctuina* var. *noctuina*, *Potonieisporites elegans* (two specimens), *Retusotriletes incohatus*, *Rugospora polyptycha*, *Schopfipollenites acadiensis* and *Schulzospora bilunata*.

Remarks: The presence of *Potonieisporites elegans* suggests an age younger than the SM Zone.

ii) GSC locality C-090448. Sample location 1.25 km south of Kennedy Point, latitude 47°48'53"N, longitude 59°20'00"W (see Figure 6). Collected from 1.5 m of grey, fine grained sandstone and lutite at the base of a 10.6 m section, which is described below. This locality is F11 of Utting (1965, Map 1).

Top of section

0 - 3.05 m+	Trough crossbedded, pebbly sandstone.
3.05 - 4.88 m	Dark grey lutite with thin, micaceous sandstone intercalations (C-090446 from upper half of bed; C-090447 from lower half of bed).
4.88 - 6.71 m	Purple speckled with green, fine grained, micaceous sandstone.
6.71 - 7.93 m	Buff, medium to coarse grained, trough crossbedded sandstone.
7.93 - 9.15 m	Purple lutite.
9.15 - 10.67 m	Grey, fine grained sandstone and lutite (C-090448).

Only sample C-090448 contained a significant spore assemblage.

Identifications: *Crassispora trychera*, *Dictyotriletes odontolophos*, *Granulatisporites granulatus*, *Granulatisporites tuberculatus*, *Knoxisporites stephanephorus*, *Knoxisporites triradiatus*, *Leiotriletes inermis*, *Lycospora noctuina* var. *noctuina*, *Punctatisporites planus*, *Raistrickia magdalena*, *Schopfipollenites acadiensis* and *Spelaeotriletes pretiosus* var. *bellii*. In addition, there were a number of specimens too poorly preserved to be identified.

Remarks: No precise concurrent range zone was determined for this single sample, and the species listed above represent only part of the assemblage, but the presence of *Granulatisporites granulatus* suggests it may be younger than the SM Zone.

Conclusions: The preservation of the samples from the Searston Formation is not good, but sufficient specimens in some samples can be identified to assign certain of these beds tentatively to the SM Zone, although others may be younger. The appearance of rare specimens of *Potonieisporites elegans* in the SM Zone suggests a Namurian A age. The frequent faulting in the section at Capelin Cove and the poor preservation of the spores makes any confident age determination difficult, and it is possible that some of the impoverished samples tentatively assigned to the SM Zone are younger.

PLATES 1-6

All figures are from unretouched negatives and prints. Transmitted light photomicrographs were taken under bright field illumination, except where indicated by the letters IC (=interference contrast illumination).

In the explanation of figures, the species name is followed by the GSC locality number, the slide number, stage co-ordinates and the GSC type number. All specimens are in the collections of the Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, Canada. The specimens photographed under the scanning electron microscope are stored on the original cover slips and have not been covered by mounting medium.

Stage co-ordinates given in the explanation of plates and in the systematic palynology section are those of Leitz Orthoplan microscope no. 9856599 of the Institute of Sedimentary and Petroleum Geology, Calgary, Alberta, Canada.

The magnification of all illustrated specimens is x500 unless otherwise stated.

PLATE 1

Figure 1. *Calamospora parva Guennel*, 1958

C-090406, SB-1-99-20A: 6.8 x 110.2, GSC 73727.

Figure 2. *Leiotriletes inermis* (Waltz) Ischenko, 1952

D-1384-8-1: 44.7 x 94.2, GSC 737[illegible].

Figure 3. *Leiotriletes ornatus* Ischenko, 1956

D-1370-98-3-2: 26.7 x 96.0, GSC 73729.

Figure 4. *Punctatisporites minutus* Kosanke, 1950

D-1384-16-1: 40.0 x 95.0, GSC 73730.

Figure 5. *Punctatisporites irrasus* Hacquebard, 1957

D-1384-7-1: 40.9 x 105.0, GSC 73731.

Figure 6. *Punctatisporites planus* Hacquebard, 1957

D-1384-11-1: 30.0 x 94.7, GSC 55421.

Figure 7. *Retusotriletes incohatus* Sullivan, 1964a

D-1370-98-3-1: 29.7 x 92.7, GSC 73732.

Figure 8. *Granulatisporites tuberculatus* Hoffmeister, Staplin and Malloy, 1955

D-1010-JS-32-72-4-2: 43.2 x 98.4, GSC 73733.

Figure 9. *Granulatisporites* sp. cf. *G. tuberculatus*

D-1384-29-30: 10.7 x 106.7, GSC 73844.

Figure 10. *Tricidarisporites arcuatus* Neville, 1973

C-090406-SB-1-99-2: 36.0 x 94.2, GSC 73734.

Figure 11. *Acanthotriletes hacquebardii* Playford, 1964

D-1534-KA-63-C-1: 41.5 x 112.4, GSC 73735.

Figures 12-14. *Anapiculatisporites fundiensis* sp. nov.

12. Holotype, D-1384-3-1: 42.0 x 108.6, GSC 73736.
13. Figured specimen 1, D-1384-3-1: 41.7 x 105.6, GSC 73737.
14. Figured specimen 2, D-1384-3-1: 42.0 x 102.0, GSC 73738.

Figure 15. *Pustulatisporites multicapitis* Bertelsen, 1972

D-1384-22-1: 32.7 x 106.2, GSC 73739.

Figure 16. *Ibrahimispores magnificus* Neves, 1961

D-1534-KA-21-1-3: 31.8 x 101.7, GSC 73740.

Figures 17-19. *Neoraistrickia versiforma* sp. nov.

17. Holotype, D-1384-6-2: 37.0 x 102.5, GSC 73741.
18. Figured specimen 1, ROM IDM-3-3-2: 35.7 x 97.3, GSC 73742.
19. Figured specimen 2, ROM IDM-3-3-2: 10.5 x 107.6, GSC 73743.

Figures 20-22. *Raistrickia magdalena* sp. nov.

20. Holotype, D-1384-32-1: 37.3 x 102.2, GSC 73744.
21. Figured specimen 1, D-1014-JS-1-72-6-1: 37.6 x 94.9, GSC 73745.
22. Figured specimen 2, D-1014-JS-1-72-6-2: 32.0 x 100.2, GSC 73746.

Figure 23. *Raistrickia baculosa* Hacquebard, 1957

D-1534-KA-63-D-2: 34.0 x 101.7, GSC 73747.

Figure 24. *Raistrickia clavata* Hacquebard emend. Playford, 1964

D-1384-21-1: 48.3 x 103.8, GSC 73748.

Figure 25. *Raistrickia nigra* Love, 1960

C-097712-14-2: 10.5 x 106.1, GSC 73749.

Figures 26-29. *Verrucosisporites papulosus* Hacquebard, 1957

26. D-1384-3-3: 35.0 x 99.4, GSC 73750.
27. D-1384-3-1: 39.5 x 96.6, GSC 73751.
28. D-1384-3-1: 44.1 x 94.3, GSC 73752.
29. Scanning electron photomicrograph x 1400, C-097708-SEM 131, GSC 73753.

PLATE 1

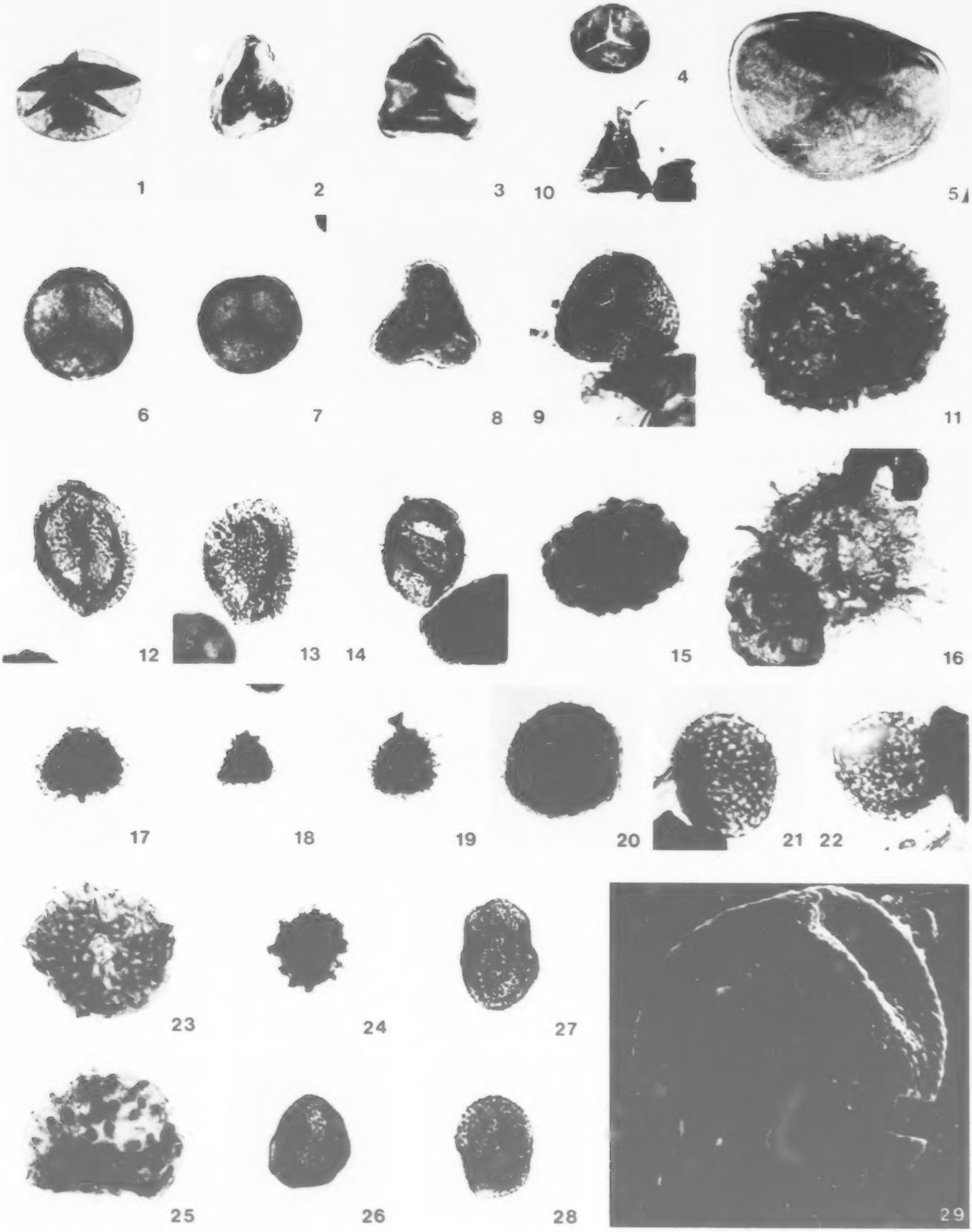

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PLATE 2

Figure 1. *Verrucosisporites morulatus* (Knox) Smith and Butterworth, 1967

D-1384-3-1: 45.0 x 105.6, GSC 73754.

Figure 2. *Verrucosisporites nitidus* (Naumova) Playford, 1964

D-1384-3-1: 40.3 x 103.2, GSC 73755.

Figure 3. *Verrucosisporites verrucosus* (Ibrahim) Ibrahim, 1933

D-1384-3-1: 28.8 x 107.0, GSC 73756.

Figure 4. *Schopfites claviger* Sullivan, 1968

C-097708-3: 32.4 x 100.7, GSC 73757.

Figures 5-7. *Convolutispora labyrinthea* sp. nov.

5. Holotype, D-1384-7-1: 38.5 x 98.6, GSC 73758.
6. Figured specimen 1, D-1384-21-1: 37.3 x 100.4, GSC 73759.
7. Figured specimen 2, D-1384-16-1: 41.6 x 100.2, GSC 73760.

Figure 8. *Convolutispora mellita* Hoffmeister, Staplin and Malloy, 1955

D-1534-KA-21-1: 33.7 x 94.5, GSC 73761.

Figure 9. *Convolutispora tessellata* Hoffmeister, Staplin and Malloy, 1955

D-1534 (GSC 7044)-KA-63-C-1: 40.6 x 108.1, GSC 73762.

Figure 10. *Convolutispora vermiformis* Hughes and Playford, 1961

D-1384-27-1: 29.5 x 103.9, GSC 73763.

Figures 11-13. *Dictyotriletes odontolophos* sp. nov.

11. Holotype, D-1384-29-23: 29.5 x 99.6, GSC 73764.
12. Figured specimen 1, D-1384-6-2: 34.6 x 99.5, GSC 73765.
13. Figured specimen 2, D-1014-JS-1-72-6-7: 31.8 x 99.5, GSC 73766.

Figures 14-16. *Microreticulatisporites hacquebardii* sp. nov.

14. Holotype, D-1384-16-1: 32.7 x 100.3, GSC 73767.
15. Figured specimen 1, ROM-Heatherton-2-9-78-PB-25-2: 33.4 x 96.0, GSC 73768.
16. Figured specimen 2, D-1384-3-1: 33.0 x 110.0, GSC 73769.

Figure 17. *Secarisporites lobatus* Neves, 1961

C-090406-99-5: 50.6 x 112.2, GSC 73770.

Figure 18. *Secarisporites remotus* Neves, 1961

D-1384-25-1: 35.5 x 110.2, GSC 73771.

Figures 19-22. *Scutulum trisupplementum* sp. nov.

19. Holotype, D-1014-JS-1-72-6-7: 33.5 x 100.3, GSC 73772.
20. Figured specimen 1, D-1014-JS-1-72-6-1: 40.6 x 105.3, GSC 73773.
21. Figured specimen 2, D-1014-JS-1-72-6-7: 44.7 x 93.8, GSC 73774.
22. Figured specimen 3, D-1384-27-1: 41.8 x 102.1, GSC 73775.

Figure 23. *Knoxisporites literatus* (Waltz) Playford, 1962

D-1384-28-1: 39.3 x 106.1, GSC 73776.

Figures 24-27. *Knoxisporites probolos* sp. nov.

24. Holotype, D-1384-16-1: 44.4 x 95.7, GSC 73777.
25. Figured specimen 1, tetrad, D-1384-27-1: 39.3 x 94.4, GSC 73778.
26. Figured specimen 2, tetrad, D-1477-58-5-1: 35.7 x 103.0, GSC 73779, illustration of proximal surface.
27. Same specimen as Figure 26, illustration of distal surface.

PLATE 2

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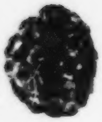
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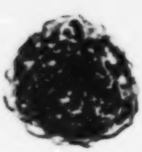
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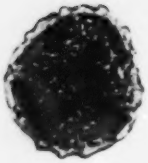
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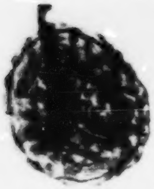
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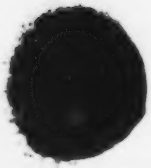
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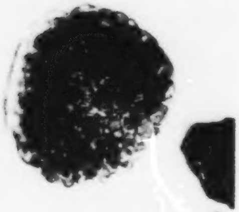
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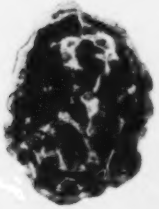
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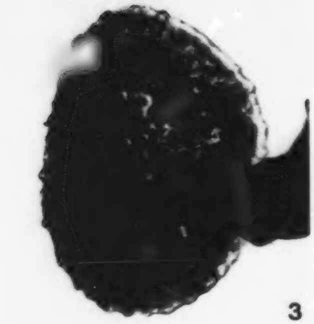
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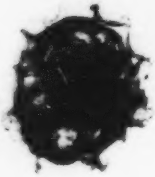
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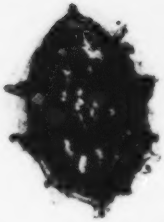
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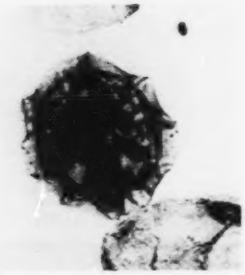
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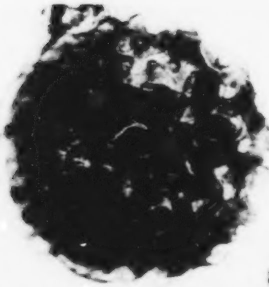
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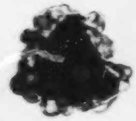
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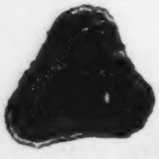
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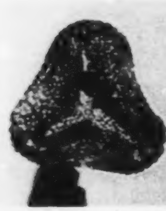
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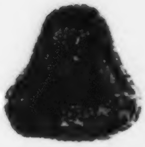
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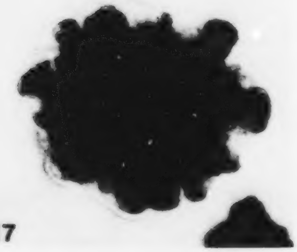
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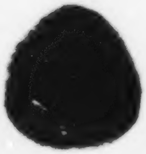
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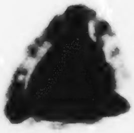
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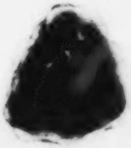
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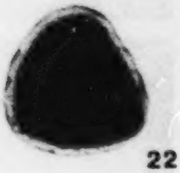
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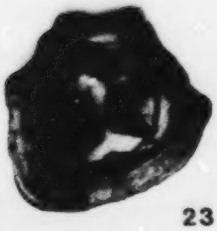
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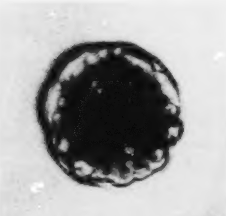
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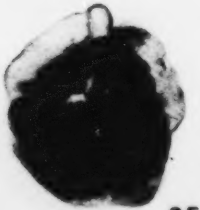
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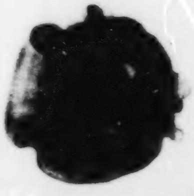
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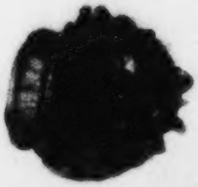
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PLATE 3

Figure 1. *Knoxisporites stephanephorus* Love, 1960

D-1534-KA-63-D: 43.0 x 75.3, GSC 73780.

Figure 2. *Knoxisporites triradiatus* Hoffmeiser, Staplin and Malloy, 1955

C-097710-1: 21.5 x 102.7, GSC 73781.

Figure 3. *Knoxisporites* sp. A

D-1384-29-30: 22.2 x 96.5, GSC 73845.

Figure 4. *Vallatisporites ciliaris* (Luber) Sullivan, 1964b

C-090406-SB-1-3-9: 38.7 x 98.0, GSC 62488.

Figure 5. *Vallatisporites verrucosus* Hacquebard, 1957

C-090406-SB-1-3-11: 38.5 x 101.0, GSC 73782.

Figures 6-8. *Crassispora trychera* Neves and Ioannides, 1974

6. D-1384-10-1: 35.3 x 93.5, GSC 73783.
7. C-097710-1: 43.7 x 101.8, GSC 73785.
8. C-097710-1: 11.7 x 101.3, GSC 73786.

Figure 9. *Cristatisporites submarginatus* (Playford) comb. nov.

Figured specimen, D-1384-3-1: 29.7 x 108.7, GSC 73787.

Figures 10-13. *Densosporites columbaris* sp. nov.

10. Holotype, GSC plant locality 1659-1: 36.4 x 101.4, GSC 73788.
11. Figured specimen 1, C-097701-2: 49.2 x 103.8, GSC 73789.
12. Figured specimen 2, C-097710-1: 20.0 x 97.3, GSC 73790.
13. Figured specimen 3, scanning electron photomicrograph x700, C-097708-SEM 129, GSC 73791.

Figure 14. *Lycospora noctuina* Butterworth and Williams, 1958, var. *noctuina*

D-1384-32-1: 36.5 x 104.5, GSC 73792.

Figure 15. *Lycospora pusilla* (Ibrahim) Schopf, Wilson and Bentall "tendance B2", Somers, 1972

C-090434-4: 31.3 x 107.9, GSC 73793.

Figure 16. *Grandispora spinosa* Hoffmeister, Staplin and Malloy, 1955

D-1325-K4-1: 35.4 x 100.1, GSC 73794.

Figure 17. *Grandispora uncata* (Hacquebard) Playford, 1971

C-090406-SB-1-99-4-4: 51.3 x 104.9, GSC 62481.

Figure 18. *Rugospora corporata* Neves and Owens, var. *verrucosa* Neville, 1968

D-1384-29-34: 15.3 x 110.7, GSC 73795.

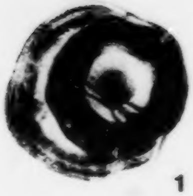
Figures 19, 20. *Rugospora minuta* Neves and Ioannides, 1974

19. C-097710-1: 21.5 x 102.7, GSC 73796.
20. Scanning electron photomicrograph, C-097708-SEM 135, GSC 73797.

Figure 21. *Rugospora polyptycha* Neves and Ioannides, 1974

D-1384-11-1: 43.2 x 102.4, GSC 73798.

PLATE 3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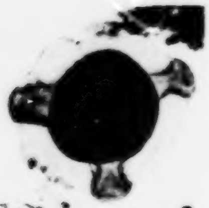
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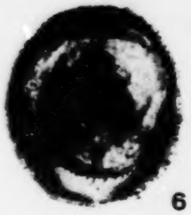
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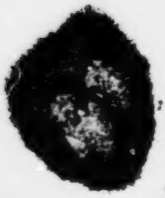
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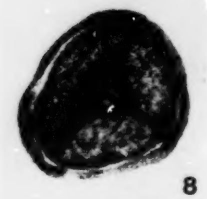
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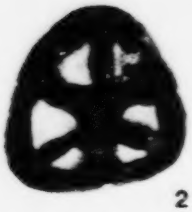
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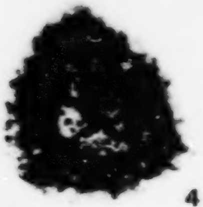
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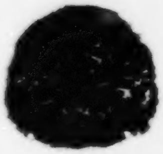
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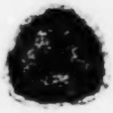
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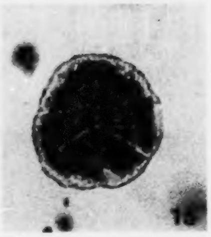
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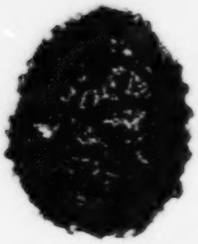
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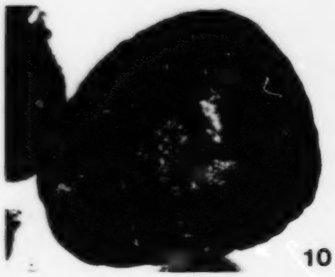
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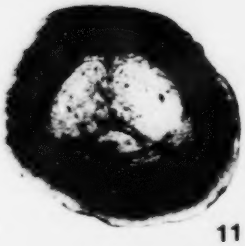
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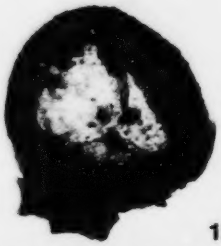
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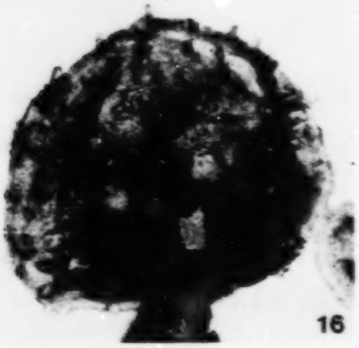
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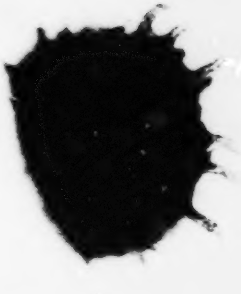
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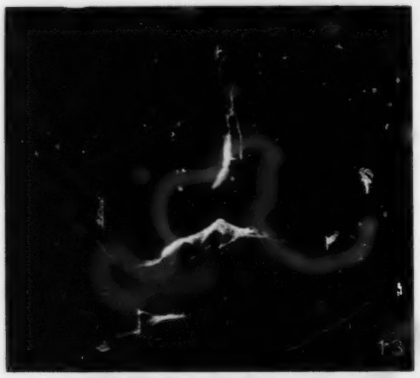
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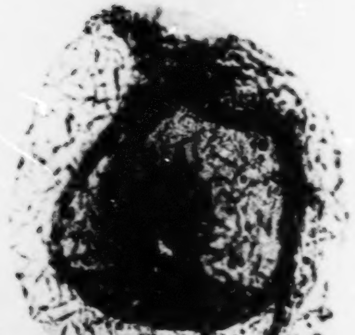
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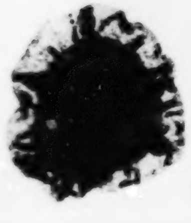
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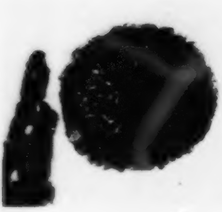
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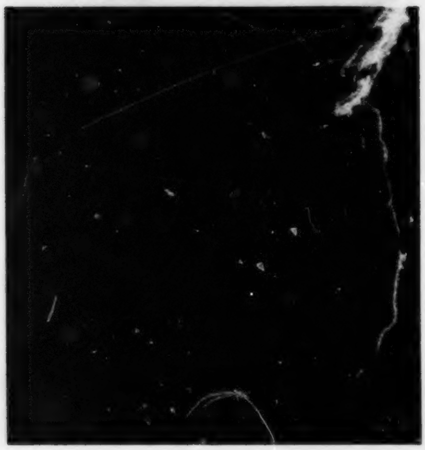


PLATE 4

Figure 1. *Spelaeotriletes pretiosus* (Playford) Neves and Belt emend. var. *pretiosus*

C-078245-1: 29.9 x 99.4, GSC 73799.

Figures 2-4. *Spelaeotriletes pretiosus* (Playford) Neves and Belt emend. var. *bellii* var. nov.

2. Holotype, C-090406-SB-1-33-4: 53.6 x 99.1, GSC 73800.
3. Figured specimen 1, D-1370-98-3-1: 33.5 x 110.5, GSC 73801.
4. Figured specimen 2, D-1384-7-3: 29.9 x 107.4, GSC 73802.

Figures 5-8. *Spelaeotriletes pretiosus* (Playford) Neves and Belt emend. var. *windsorensis* var. nov.

5. Holotype, D-1384-29-1: 42.4 x 102.7, GSC 73803.
6. Figured specimen 1, C-097710-1: 19.1 x 100.3, GSC 73804.
7. Figured specimen 2, C-097704-2: 19.5 x 95.9, GSC 73805.
8. Figured specimen 3, scanning electron photomicrograph x750, slide C-097708-SEM 130, GSC 73806.

Figures 9-12. *Spelaeotriletes echinatus* Hacquebard comb. nov. and emend.

9. Holotype, D-1384-3-1: 46.5 x 107.8, GSC 73807.
10. Figured specimen 1, D-1384-3-1: 33.2 x 103.1, GSC 73808.
11. Figured specimen 2, D-1384-3-4: 34.0 x 94.3, GSC 73809.
12. Detail of ornament (x1000) of specimen illustrated in figure 11.

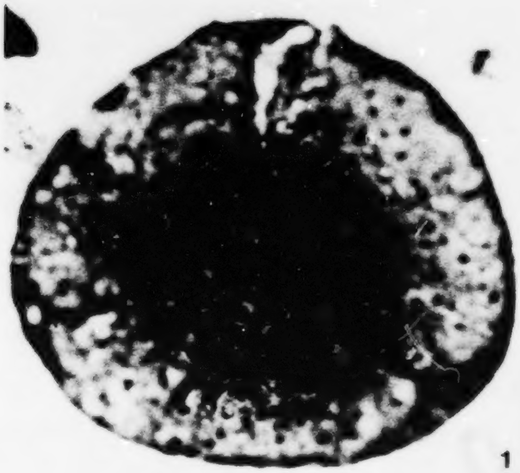
Figures 13-16. *Spelaeotriletes tuberosus* sp. nov.

13. Holotype, D-1384-7-1: 41.7 x 101.8, GSC 73810.
14. Figured specimen 1, D-1384-23-1: 41.8 x 104.6, GSC 73811.
15. Figured specimen 2, C-097704-2: 18.3 x 103.4, GSC 73812.
16. Figured specimen 3, scanning electron photomicrograph (x5500), detail of ornament, C-097708-SEM 138, GSC 73813.

Figures 17-19. *Discernisporites barssii* sp. nov.

17. Holotype, D-1384-14-1: 46.0 x 98.3, GSC 73814.
18. Figured specimen 1, D-1014-JS-1-72-6-7: 33.0 x 102.3, GSC 73815.
19. Figured specimen 2, D-1384-7-3: 17.4 x 102.3, GSC 73816.

PLATE 4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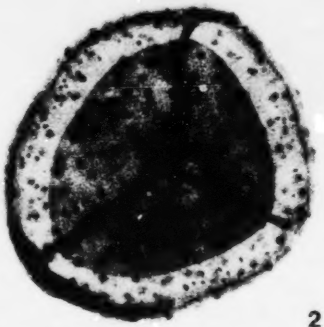
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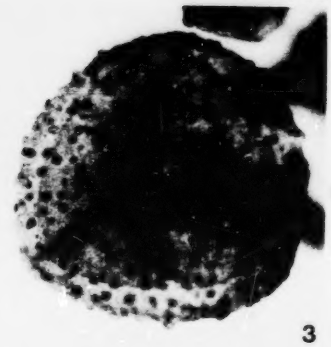
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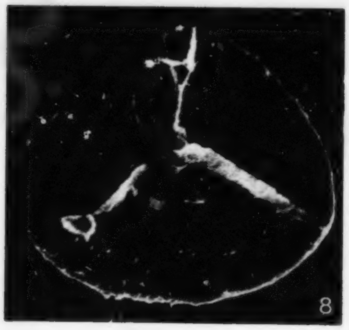
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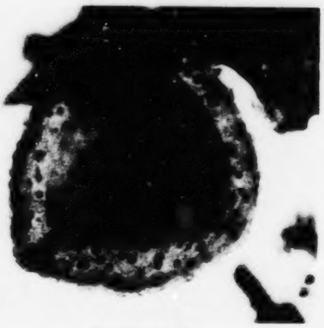
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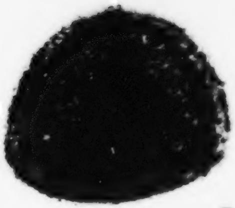
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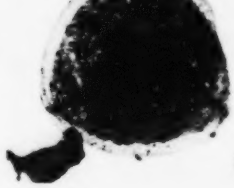
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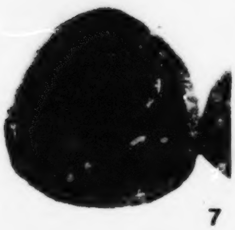
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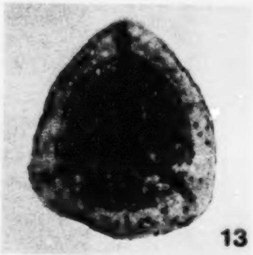
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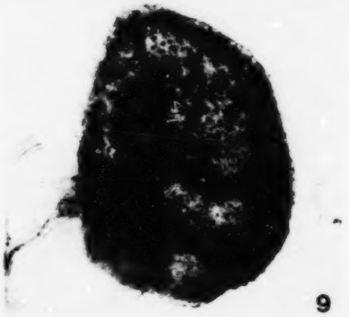
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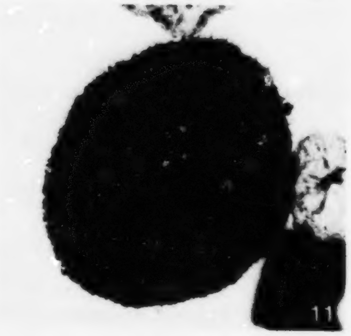
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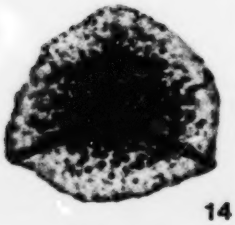
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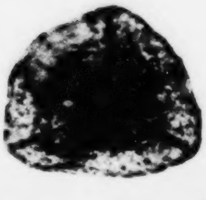
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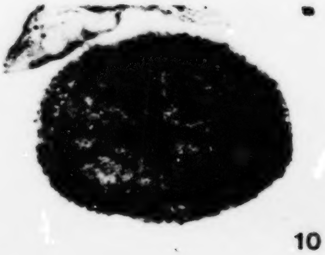
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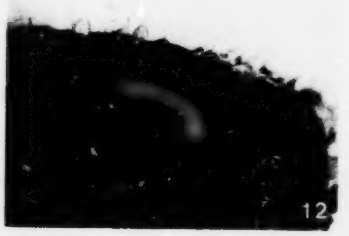
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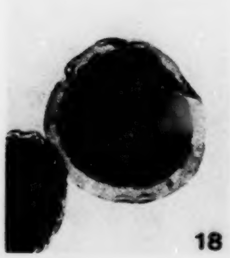
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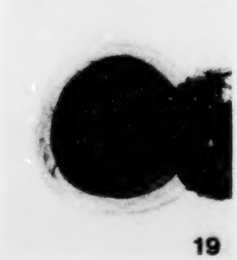
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PLATE 5

Figures 1-3. *Discernisporites diaphanes* sp. nov.

1. Holotype, D-1384-16-1: 45.0 x 105.8, GSC 73817.
2. Figured specimen 1, D-1384-16-1: 34.5 x 94.3, GSC 73818.
3. Figured specimen 2, C-090406-SB-1-21-5: 35.0 x 99.6, GSC 73819.

Figure 4. *Discernisporites macromanifestus* (Hacquebard) comb. nov.

C-090406-SB-1-8-3: 45.4 x 104.5, GSC 62480.

Figures 5, 6. *Discernisporites micromanifestus* (Hacquebard) Sabry and Neves, 1971

5. C-090406-SB-1-99-6: 43.8 x 106.0, GSC 62489.
6. D-1384-16-1: 37.6 x 105.7, GSC 73820.

Figures 7-11. *Schopfipollenites acadiensis* sp. nov.

7. Holotype, D-1384-23-1: 44.4 x 101.3, GSC 73821.
8. Figured specimen 1, D-1384-23-1: 29.5 x 95.7, GSC 73822.
9. Figured specimen 2, D-1384-28-1: 44.6 x 96.3, GSC 73823.
10. Figured specimen 3, D-1384-21-1: 30.7 x 98.7, GSC 73824.
11. Figured specimen 4, scanning electron photomicrograph (x 850), C-097708-SEM 132, GSC 73825.

Figure 12. *Auroraspora macra* Sullivan, 1968

GSC plant locality 1659-1: 7.5 x 112.5, GSC 73826.

Figure 13. *Auroraspora solisortus* Hoffmeister, Staplin and Malloy, 1955

D-1384-7-2: 41.4 x 102.7, GSC 73827.

Figure 14. *Colatisporites decorus* (Bharadwaj and Venkatachala) Williams, 1973

D-1384-10-1: 43.3 x 102.0 , GSC 83360.

Figures 15-17. *Schulzospora bilunata* sp. nov.

15. Holotype, C-090406-SB-1-99-5: 40.8 x 104.3, GSC 62504.
16. Figured specimen 1, C-090406-SB-1-99-6: 49.6 x 100.6, GSC 73828.
17. Figured specimen 2, C-090406-SB-1-99-2: 45.5 x 103.6, GSC 73829.

Figure 18. *Chomotriletes multivittatus* Playford, 1978

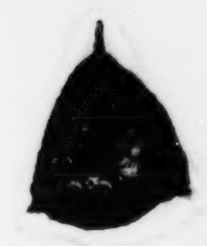
D-1010-JS-32-72-5-2: 34.4 x 102.5, GSC 73830.

Figures 19, 20. *Biannulatisphaerites simplex* Neville, 1973

18. C-097708-5-3: 42.8 x 98.0, GSC 73831.
19. C-097708-5-3: 25.1 x 99.7, GSC 73832.

Figure 21(IC). *Actinotodissus* sp. A

D-1384-33-1: 29.5 x 105.4, GSC 73833.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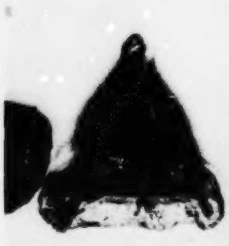
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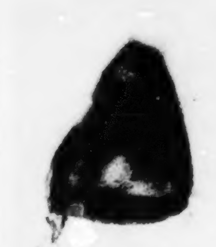
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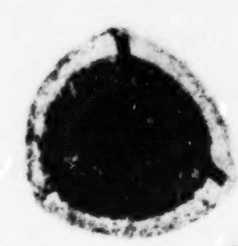
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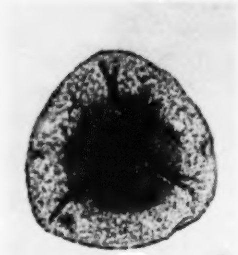
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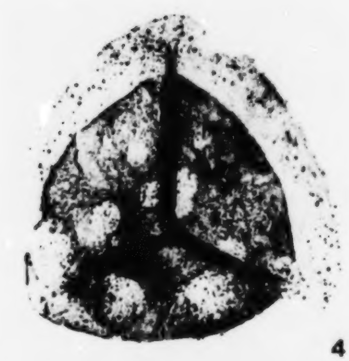
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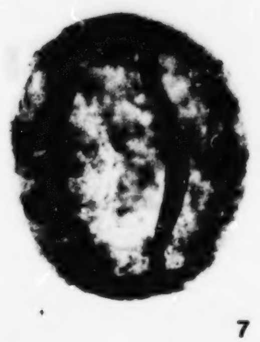
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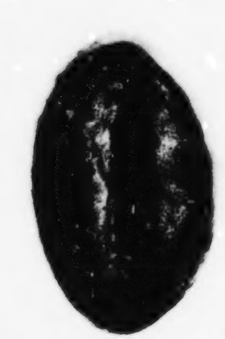
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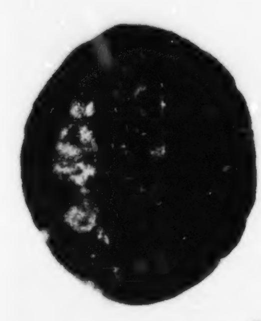
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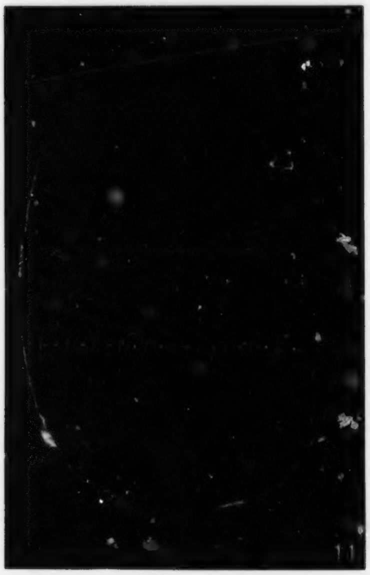
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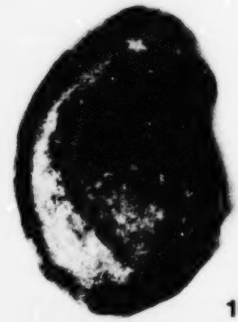
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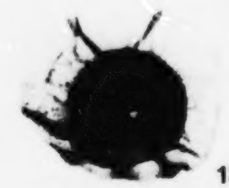
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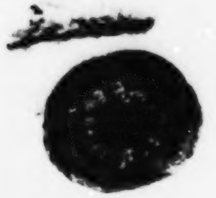
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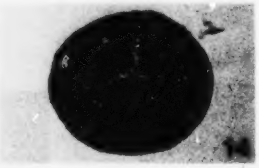
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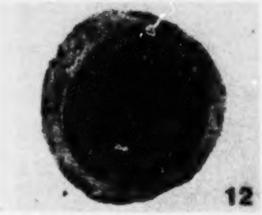
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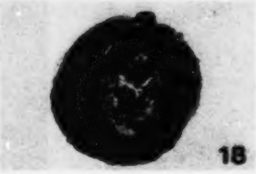
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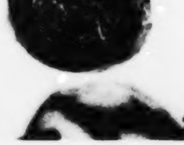
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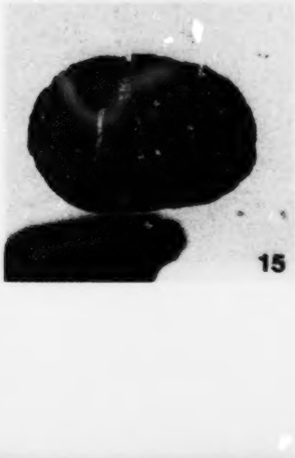
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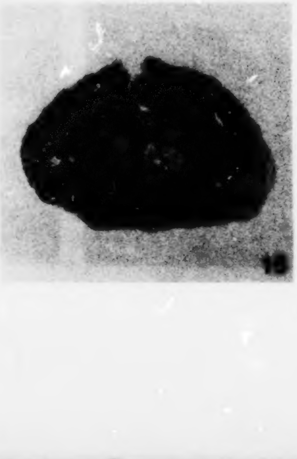
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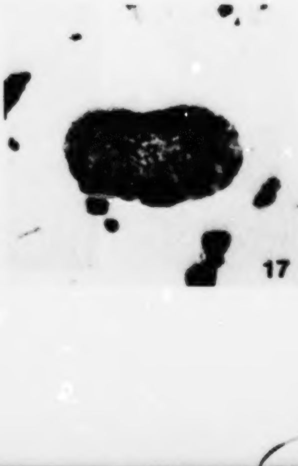
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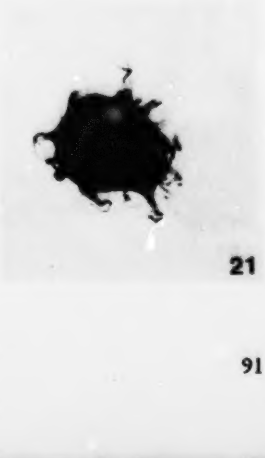
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PLATE 6

Figures 1-4. *Eisenackidium playfordii* sp. nov.

1(IC). Holotype, D-1384-29-1: 41.4 x 102.0, GSC 73835.
2(IC). Figured specimen 1, D-1384-7-2: 38.2 x 99.4, GSC 73835.
3(IC). Figured specimen 2, D-1384-7-2: 38.0 x 100.5, GSC 73836.
4(IC). Detail of ornament (x1200) on process of specimen illustrated in figure 1.

Figure 5(IC). *Micrhystridium*? sp.

D-1010-JS-72-5-1: 36.4 x 94.7, GSC 73837.

Figure 6(IC). *Elektoriskos* sp. A

C-090423-2: 13.0 x 107.0, GSC 73838.

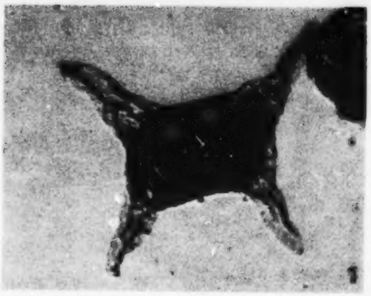
Figures 7-11. *Leiosphaeridia*? *scotia* sp. nov.

7. Holotype, C-097708-3: 30.5 x 96.3, GSC 73839.
8. Figured specimen 1, C-097708-3: 45.6 x 103.2, GSC 73840.
9. Figured specimen 2, C-097708-2: 24.4 x 110.0, GSC 73841.
10. Figured specimen 3, scanning electron photomicrograph (x750), C-097708-SEM 140, GSC 73842.
11. Scanning electron photomicrograph showing details (x1700) of folding on same specimen as in figure 10, SEM 141.

Figure 12. *Leiosphaeridia*? sp. A

D-1384-11-2: 34.4 x 109.3, GSC 73843.

PLATE 6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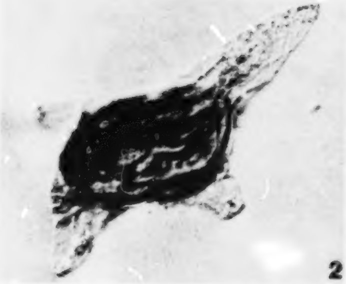
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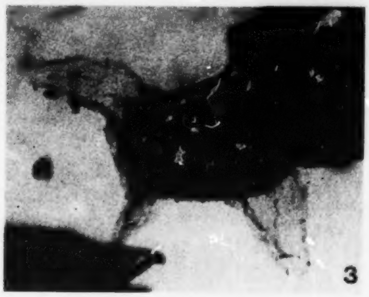
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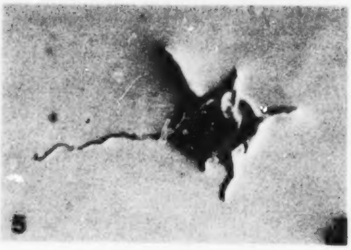
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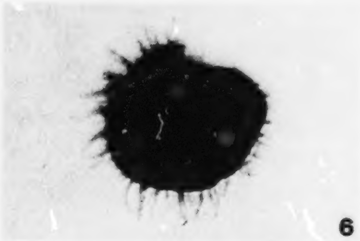
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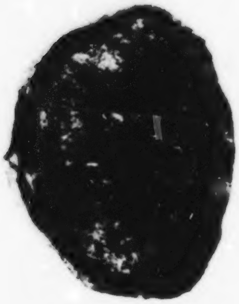
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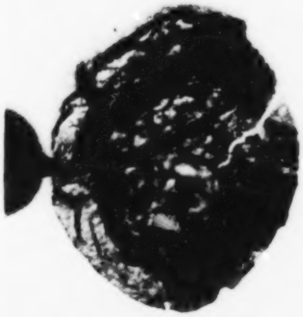
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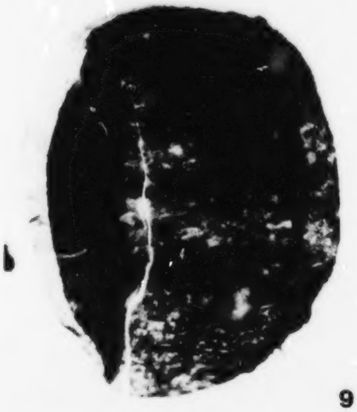
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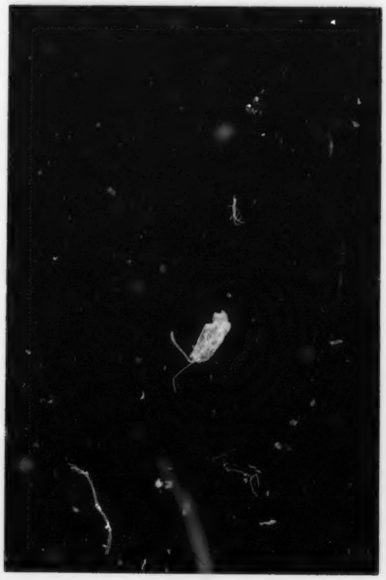

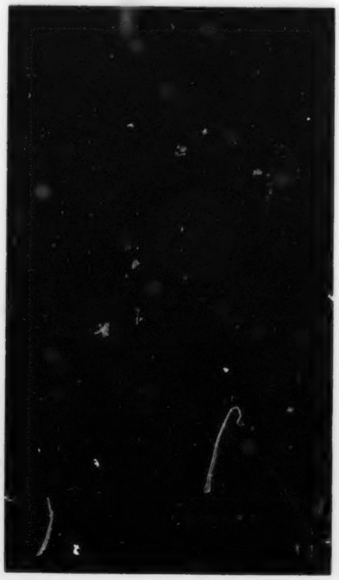

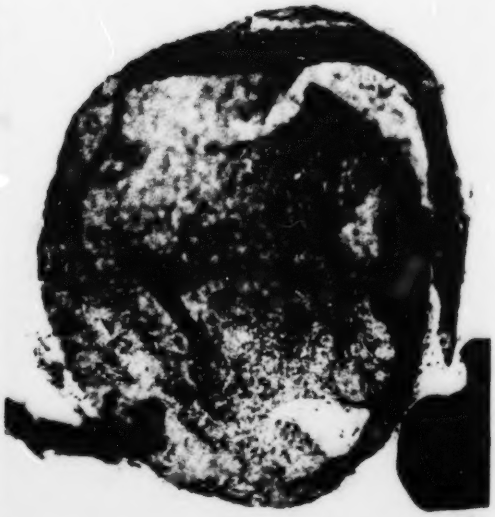
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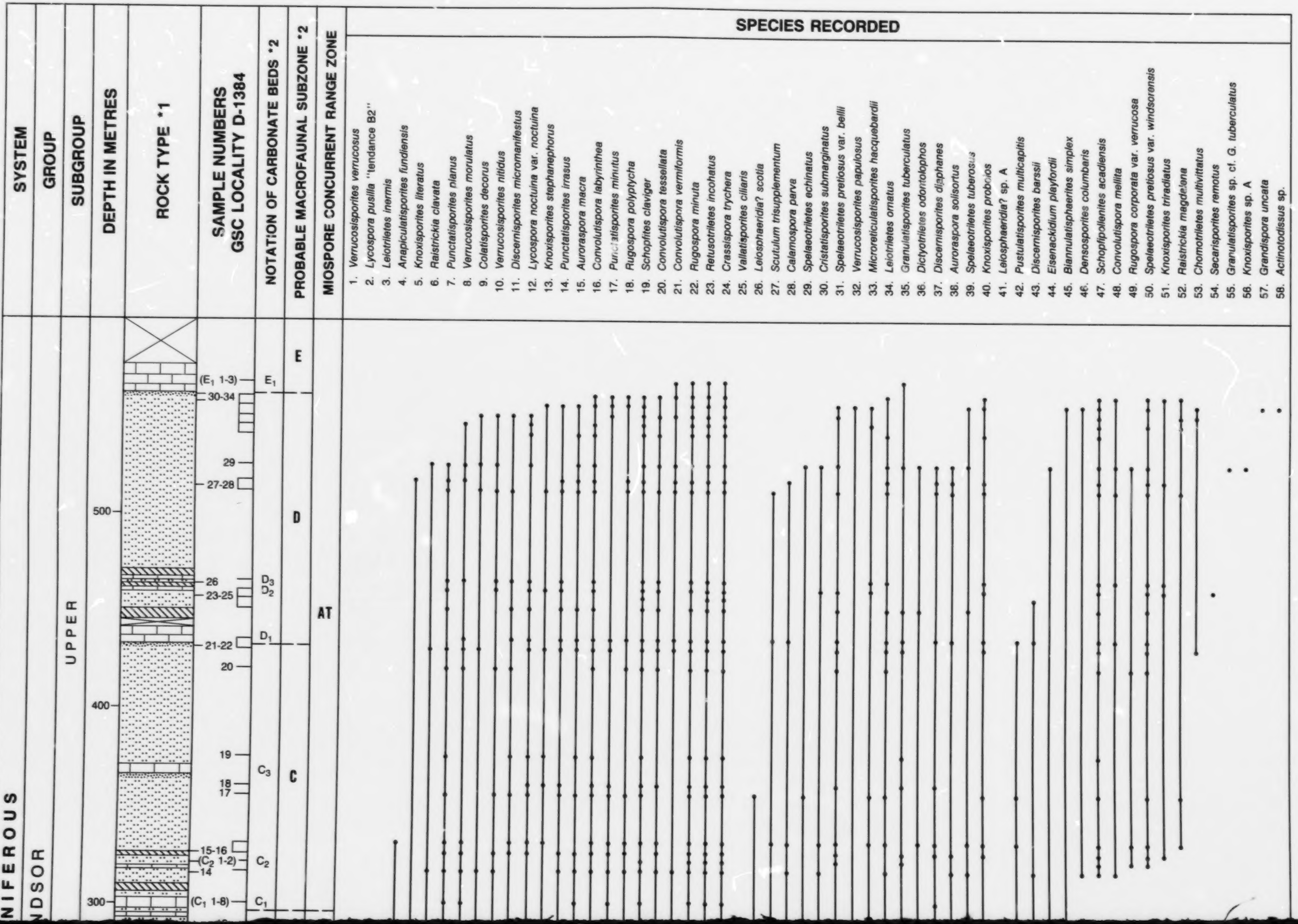
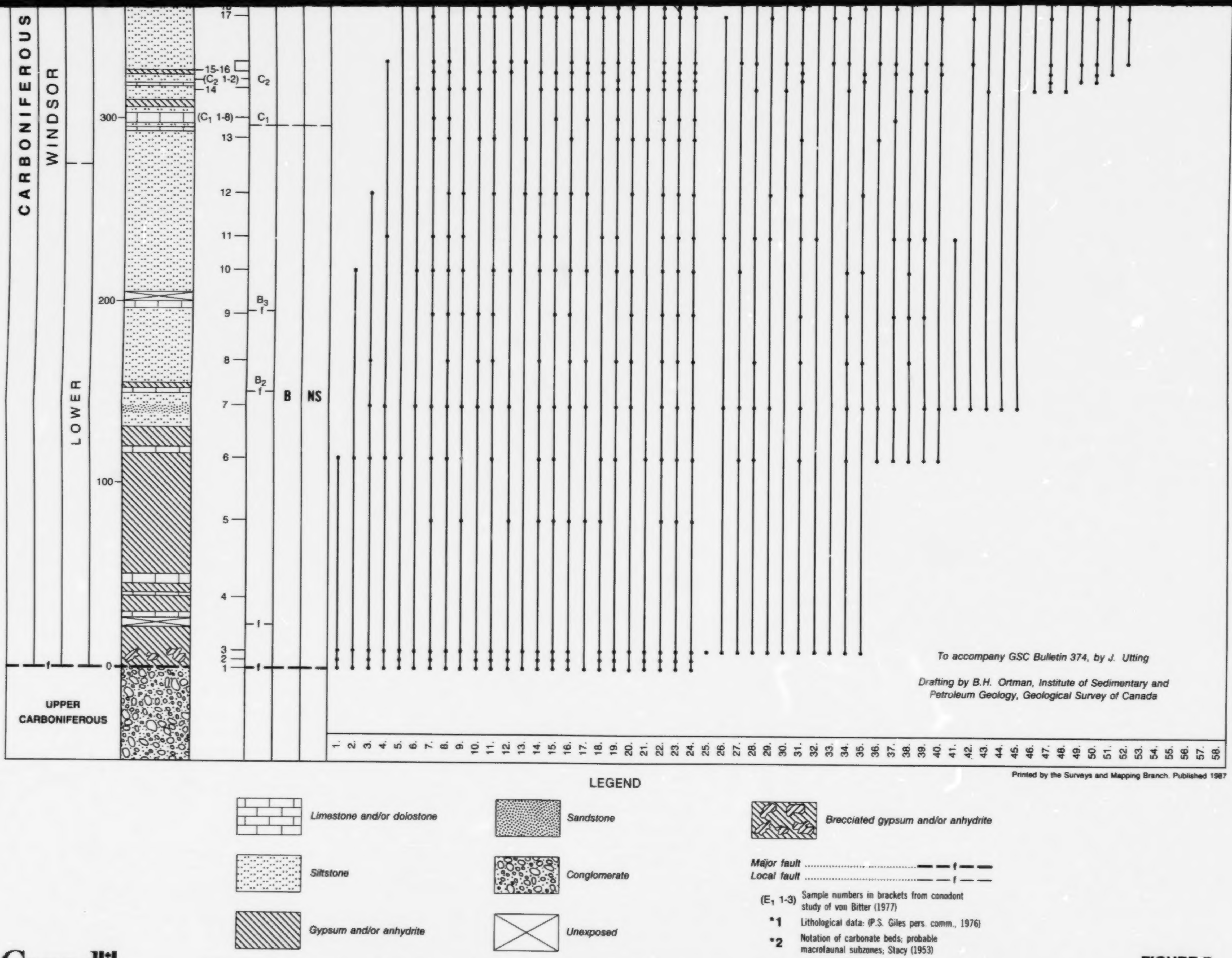
DEPARTMENT OF ENERGY, MINES AND RESOURCES
MINISTÈRE DE L'ÉNERGIE, DES MINES ET DES RESSOURCES





To accompany GSC Bulletin 374, by J. Utting

Drafting by B.H. Ortman, Institute of Sedimentary and Petroleum Geology, Geological Survey of Canada

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Figure 7. Vertical distribution of miospores in the Port Hood Island section, Cape Breton Island, Nova Scotia

FIGURE 7
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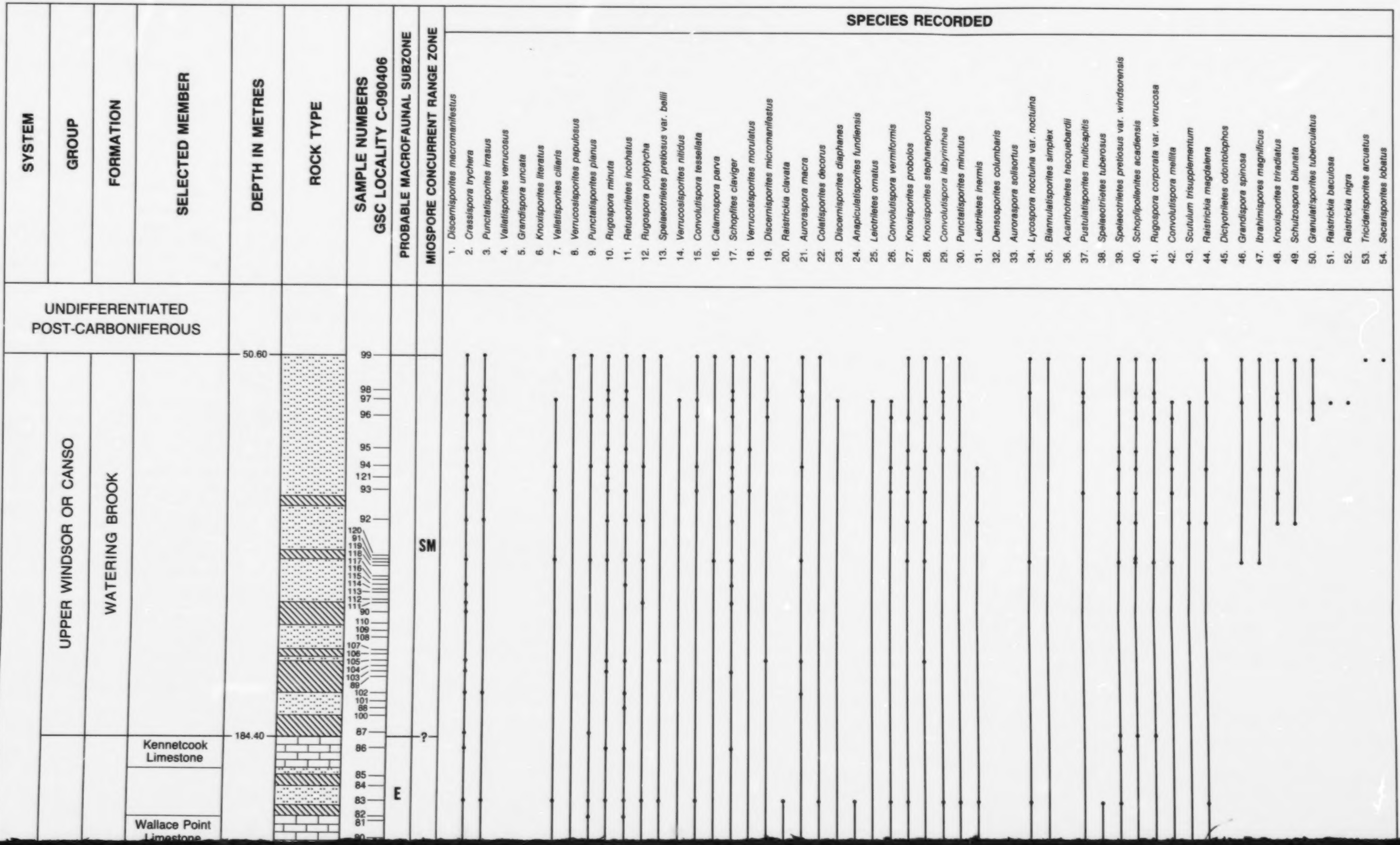
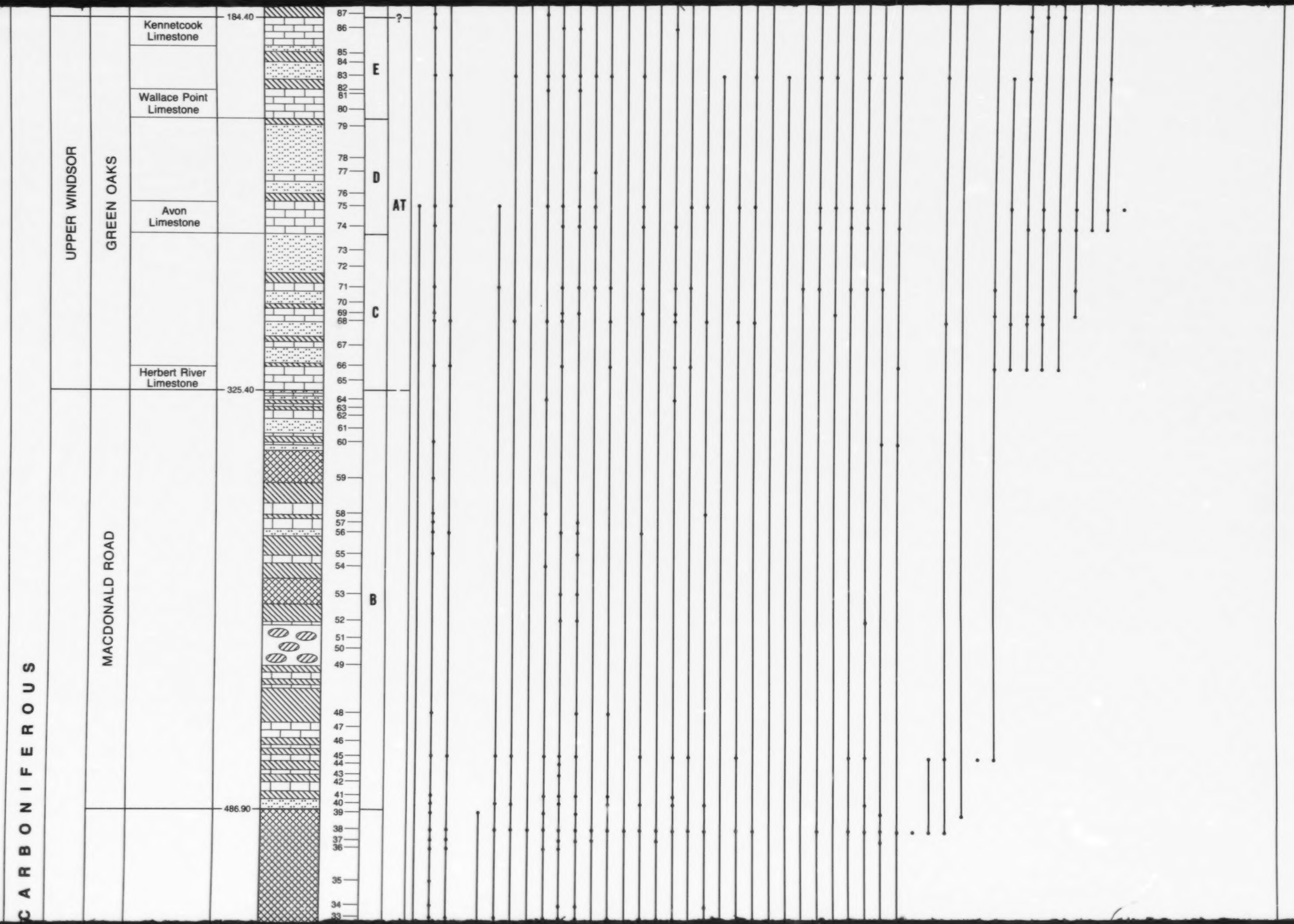
DEPARTMENT OF ENERGY, MINES AND RESOURCES
MINISTÈRE DE L'ÉNERGIE, DES MINES ET DES RESSOURCES




CARBONIFEROUS
UPPER WINDSOR
GREEN OAKS
MACDONALD ROAD
Kennetcook Limestone
Wallace Point Limestone
Avon Limestone
Herbert River Limestone
184.40
325.40
486.90
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86
85
84
83
82
81
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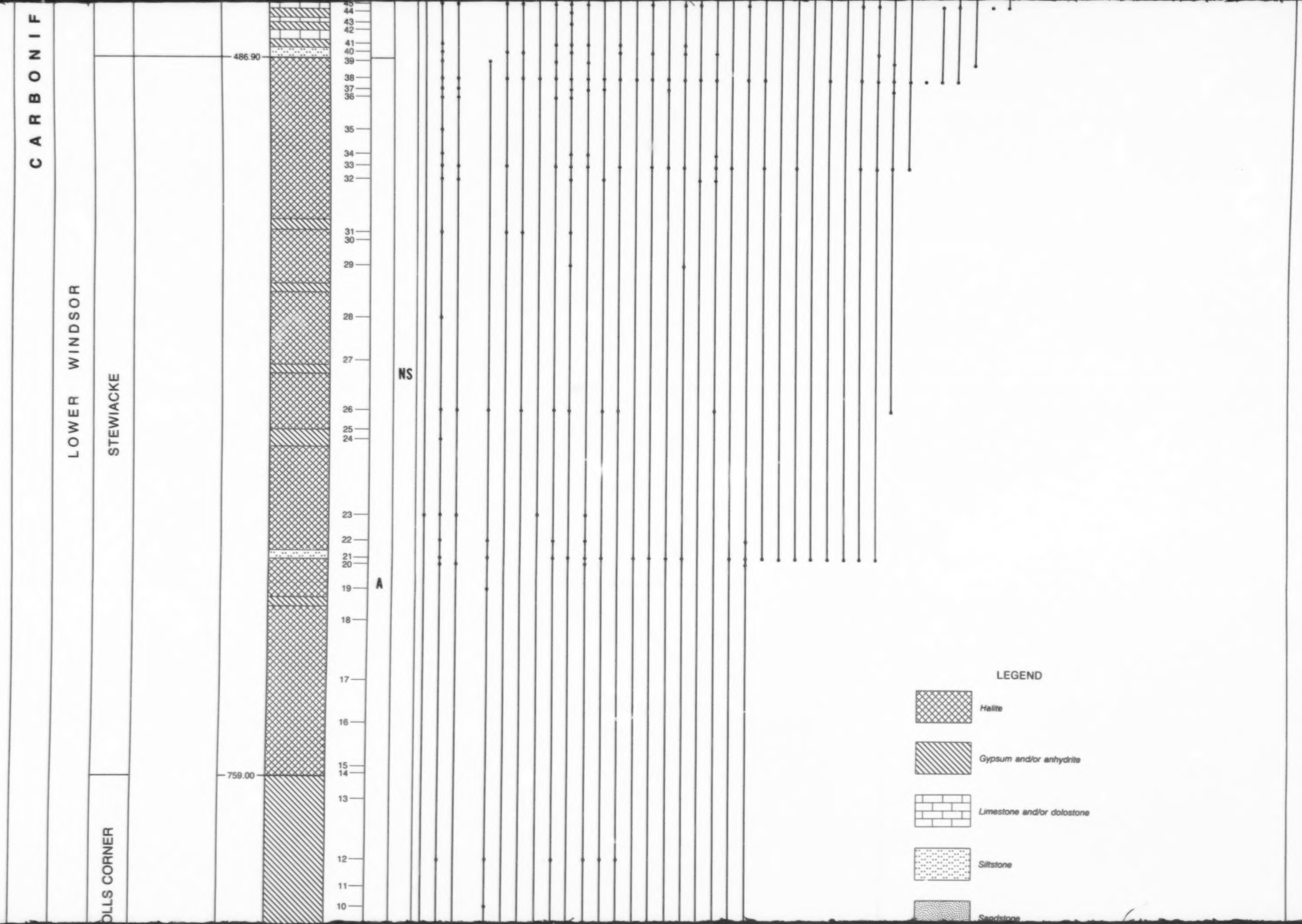

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OLLS CORNER
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Halite
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Limestone and/or dolostone
Siltstone
Sandstone

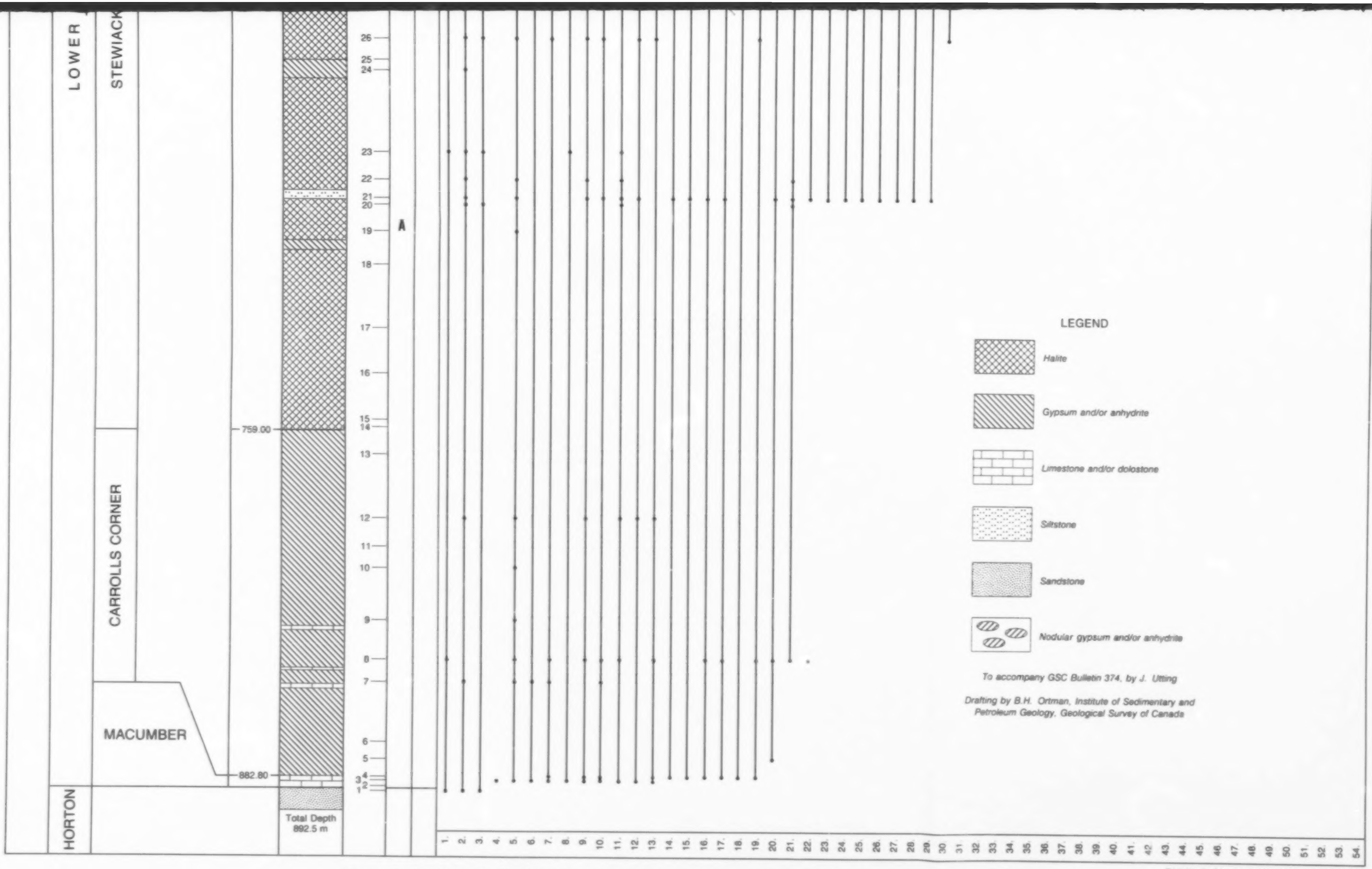

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Figure 9. Vertical distribution of miospores in Stewiacke borehole SB-1, Shubenacadie, Nova Scotia

FIGURE 9
GSC Bulletin 374